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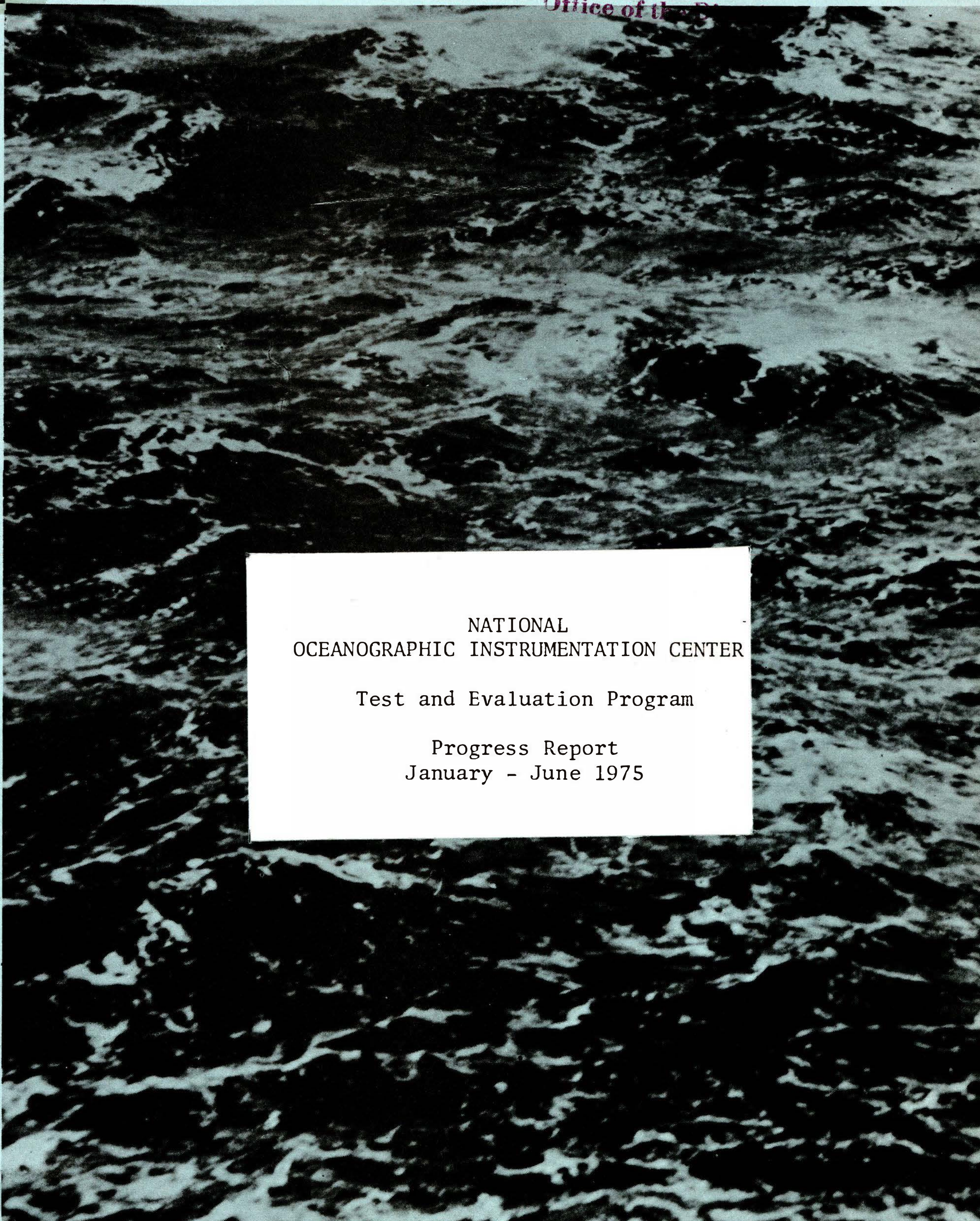

NATIONAL OCEANOGRAPHIC INSTRUMENTATION CENTER

Test and Evaluation Program

Progress Report
January - June 1975

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Center
IINGTON, D.C.

NATIONAL
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Test and Evaluation Program

Progress Report
January - June 1975

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1776-1976

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OCEANOGRAPHIC INSTRUMENTATION CENTER

Test and Evaluation Program

Progress Report
January - June 1975

Approvals:

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Chief, Evaluation Branch

July 1975

INTRODUCTION

The objective of the National Oceanographic Instrumentation Center's (NOIC) Test and Evaluation Program is to provide information on the state of marine instrument technology. This information can serve as a basis for decisions influencing positive direction of programs which utilize marine instruments and thus result in favorable changes.

The progress report provides summary descriptions of marine instrumentation undergoing test and evaluation at NOIC during the period from January 1, 1975 to June 30, 1975. The instrumentation are divided into the following five broad categories:

Acoustic Instrumentation
Conductivity/Salinity-Temperature-Depth Measuring Systems
Current Measuring Instrumentation
Water Quality Instrumentation
Wave and Tide Measuring Instrumentation

The instruments covered in this report are of general interest to the entire marine science community and of specific interest to many programs. As indicated by the asterisks in the table of contents, the majority of the instruments tested are of specific interest to the Navy and their selection was based on requirements conveyed to NOIC by the Office of the Oceanographer of the Navy.

Should anyone desire additional information concerning the evaluation of the instruments listed in this report, please contact NOIC's Testing Division, Code C631, Rockville, MD 20852 (Phone 202-426-9073 or 202-426-9075).

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*Requirements conveyed to NOIC by OCEANAV

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ACOUSTIC INSTRUMENTATION

TESTING PROGRAM

Date: July 1, 1975

Project: Acoustics

Project Leader: K. Berstis

N — Navy
I — In-House
R — Reimbursable
O — Other

Task Description	FY'75												FY'76												Req'mt.
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	
Acoustic Release Systems																									
AMF Sea Link 301	■	■	■	■					■	■															
AMF 322 Release																									N
Marine Resources Release				■	■	■	■	■	■	■	■	■	■	■											N
Side Scan Sonar																									
Klein Associates MK-300															■	■	■	■	■	■	■	■	■		N
Bottom/Subbottom Profiling Systems																									
Raytheon UGR-196C	■	■	■	■	■	■	■	■																	N
Digital Depth Trackers																									
Edo Western 261C																■	■	■	■	■	■	■	■		N,I
Raytheon PDD-200C																				■	■	■	■	■	N
Innerspace Technology																									
Model 410																					■	■	■	■	N
Model 408																				■	■	■	■	■	N
Correlation Echo Sounder Processor																									
Raytheon CESP-I	■	■																							N,I

AMF (301-322) RECOVERABLE ACOUSTIC TRANSPONDER/RELEASE SYSTEM

A. Description

The Model 301 Acoustic Relocation System and the Model 322 Recoverable Acoustic Transponder described below are designed to provide an acoustic link permitting the marking, locating, and recovery of instrument packages or other items from the sea floor.

The 301 system consists of a coder and a power amplifier (both designated Model 200) and a receiver and a transducer (both designated Model 301). The basic command signal is a five-level pulse train coded as follows: (1) carrier frequency, (2) modulation frequency, (3) pulse width, (4) pulse repetition frequency, and (5) time duration. These parameters are varied to produce three different codes for the inhibit, confirmation reply/enable, and release commands. The transpond command consists of a single-frequency burst with manual or repetitive choice. The output level of the coder is sufficient to drive the power amplifier, which in turn drives the projector in the transducer.

The transducer also contains three hydrophones each having a wide-band preamplifier. Transponder interrogations are synchronized with the receiver timing circuits. In addition, the receiver, a high gain and hard-limiting amplifier, must detect the reply signals and determine (slant) range and bearing to the transponder. When the Model 322 transponder is interrogated, the operator receives an audio reply signal, a digital indication of range, and a bearing indication by means of a 180-degree meter display with bow and stern reference lights.

The transponder is released from the mooring ballast by a coded command generated by the Model 200 coder. Upon release, the pulse repetition frequency (PRF) of the timed pinger mode is changed to confirm release. When commanded in the timed pinger mode, the transponder transmits pinger bursts for 60 seconds.

B. Progress

The evaluation of this acoustic release system was completed in April 1975. A summary of the evaluation tests follows:

PERFORMANCE TESTS - MODEL 301 ACOUSTIC RELOCATION SYSTEM

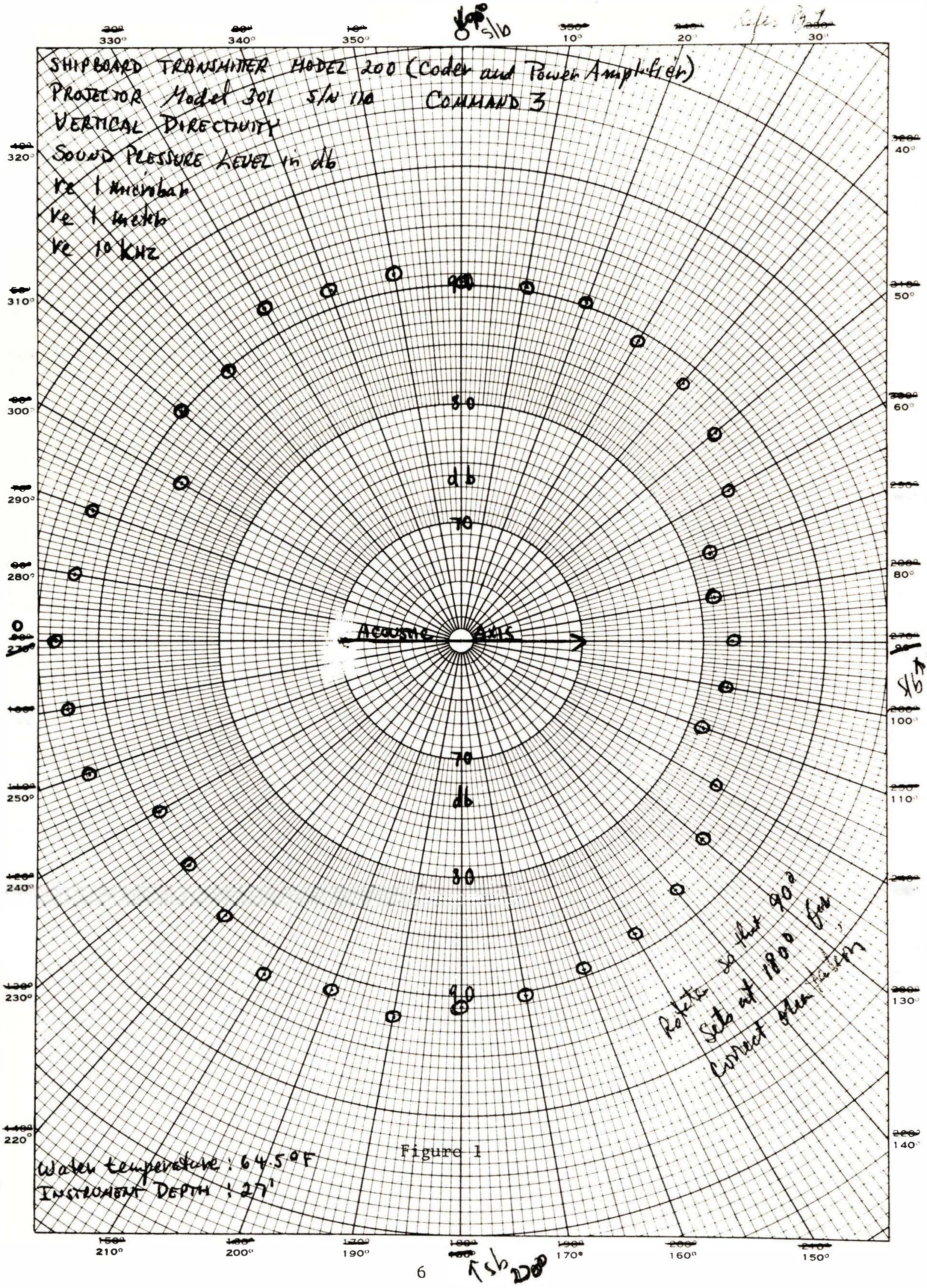
Coder Frequencies	Within specifications

Command Code Structure	Controlled wave train modulated double sideband suppressed carrier
Pulse repetition rate (3 ea.)	9, 13.5, and 21 Hz
Modulation frequencies (10 ea.)	327, 379.3, 428.8, 480.1, 528.9, 578.5, 628.4, 677.3, 729.6, 780.7 Hz
Suppressed carrier (1 ea.)	9934 Hz
Command code duration	Manual control
Transpond Code Structure	
Pulse repetition rate	Single acting (automatic option with range indicator)
Pulse width	Fixed
Command Code Source Levels	
Transpond (9 kHz)	91 dB[1]
Transpond (11 kHz)	89.4 dB
Channel 1	90.6 dB
Channel 2	90.8 dB
Channel 3	90.9 dB
Mean Source Level	
x axis (360°), normal to acoustic axis SPL	91.0 dB (omnidirectional ±0.3 dB)
Y axis (180°), lower hemispere SPL	85.8 dB ±4.6 dB See Figure 1

Effects of Supply Voltage variation:

On Coder suppressed Carrier Frequency	1 Hz change
On Coder Modulation Frequency	0 Hz change
On Coder Pulse Repetition Rate	0 Hz change

[1] All acoustic levels are in dB re 1 μbar at 1 meter unless otherwise noted.



SHIPBOARD TRANSMITTER MODEL 200 (Coder and Power Amplifier)
PROJECTOR Model 301 S/N 110 COMMAND 3
VERTICAL DIRECTIVITY
SOUND PRESSURE LEVEL in db
re 1 microbar
re 1 meter
re 10 KHz

Rotate so that 90° Sets at 180° for Correct [illegible]

Water temperature : 64.5°F
INSTRUMENT DEPTH : 27'

Figure 1

Receiver Characteristics

Audio[2] Threshold normal to Acoustic Axis	-17.7 ±2.3 dB
Firm Copy Normal to Acoustic Axis	-8.45 ±1.85 dB (See Figure 2)
[3]True Bearing vs. Indicated Bearing	See Figure 3
[4]Simulated Bearing Test	
Starboard Bearing Signal Input vs. Theoretical Starboard Heading	See Figure 4
Port Bearing Signal Input vs. Theoretical Port Heading	See Figure 5
MDL (Minimum Detectable Audio Level[2])	-94 dB re 100 mv rms
Input Signal-to-noise Ratio[5]	Probability of detection with a simulated return signal per 100 samples
Ranging 6.5 dB	51%
7.0 dB	63%
8.6 dB	83%
Bearing 11.0 dB	All bearing readings within specified bearing accuracy

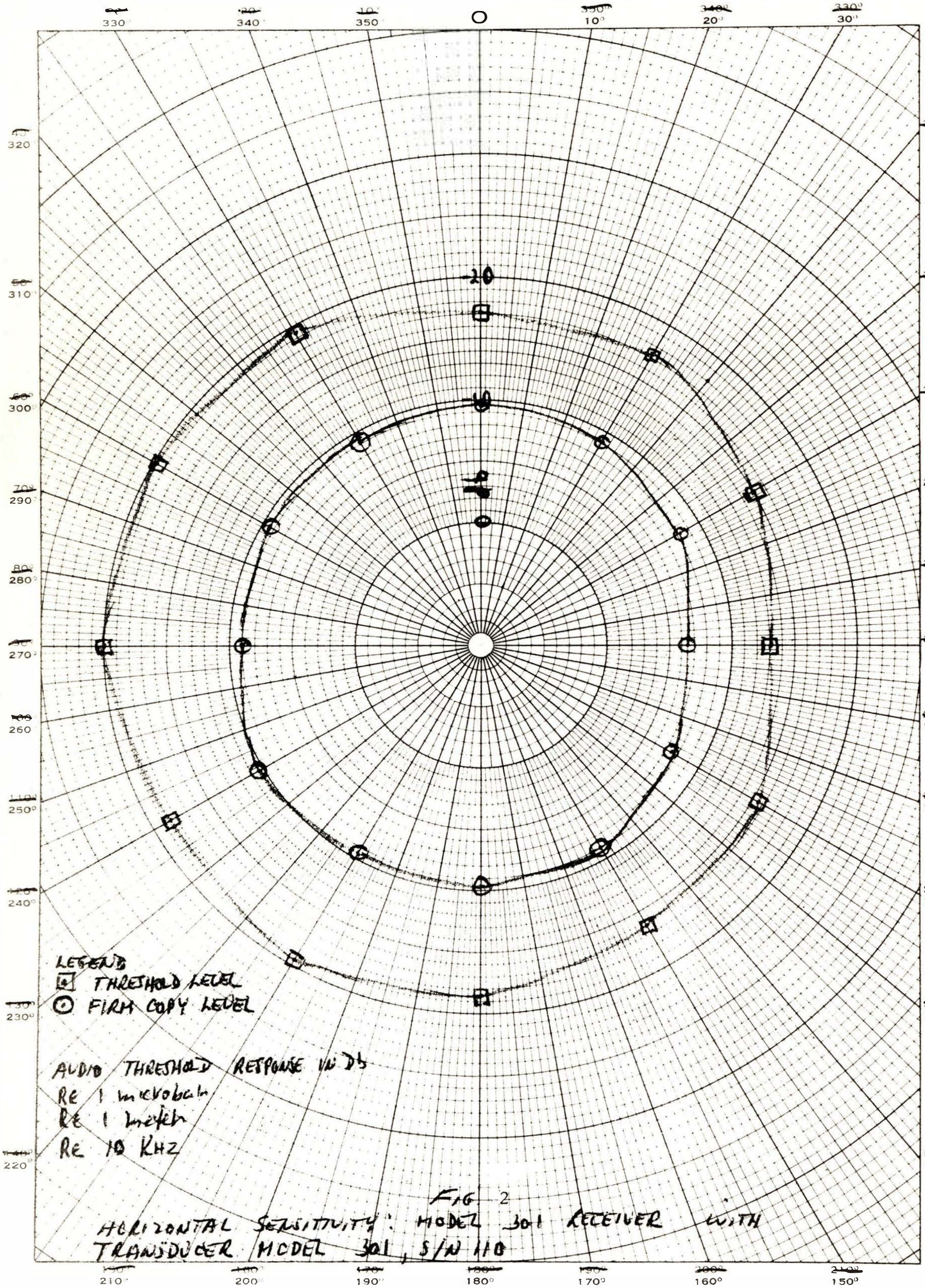
---

[2] Audio threshold is defined as the input signal level required to detect a timed ping or transponder signal 50% of the time.

[3] All acoustic calibration and true bearing tests were performed at the NOL Acoustic Facility, Brighton Dam, Maryland.

[4] The simulated bearing tests were performed by producing a synthetic input signal to the receiver and using filters to shift the phase angle to represent hydrophone signals.

[5] The input noise was measured in 492 Hz equivalent noise bandwidth. The manufacturer's specified signal-to-noise ratios were measured with an equivalent noise bandwidth of 6.28 kHz.



LEGEND
▣ THRESHOLD LEVEL
⊙ FIRM COPY LEVEL

AUDIO THRESHOLD RESPONSE IN Db
RE 1 microbar
RE 1 meter
RE 10 KHZ

FIG 2
HORIZONTAL SENSITIVITY: MODEL 301 RECEIVER WITH TRANSDUCER MODEL 301, S/N 110

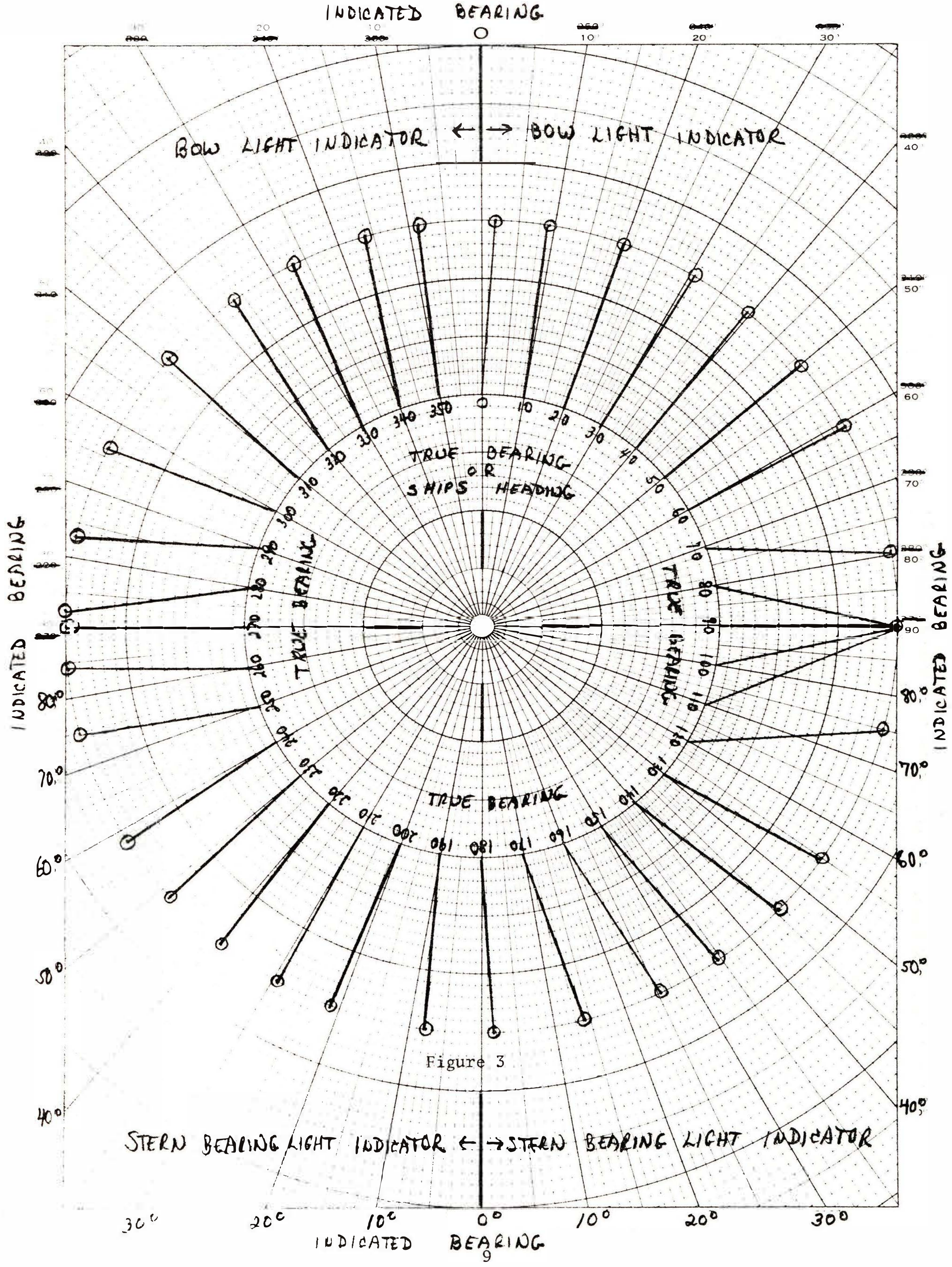
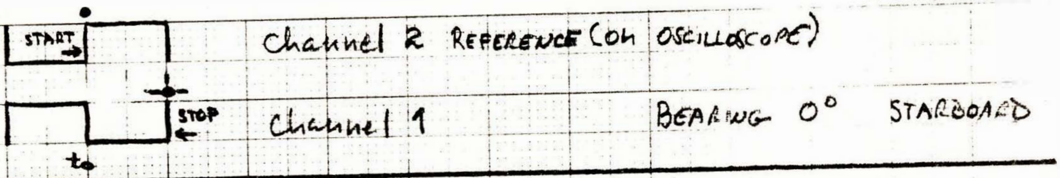
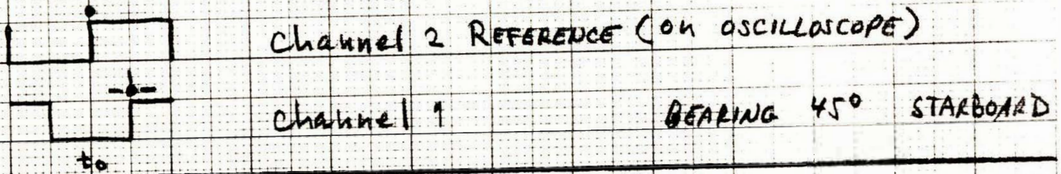

INDICATED BEARING
0
~~330~~ 30
~~340~~ 20
~~350~~ 10
~~350~~ 10°
~~340~~ 20°
~~330~~ 30°
BOW LIGHT INDICATOR ← → BOW LIGHT INDICATOR
40°
50°
60°
70°
80°
90
80°
70°
60°
50°
40°
TRUE BEARING OR SHIPS HEADING
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
TRUE BEARING
TRUE BEARING
TRUE BEARING
INDICATED BEARING
INDICATED BEARING
80°
70°
60°
50°
40°
STERN BEARING LIGHT INDICATOR ← → STERN BEARING LIGHT INDICATOR
30°
20°
10°
0°
10°
20°
30°
INDICATED BEARING
EUGENE DIETZGEN CO.
MADE IN U.S.A.

Figure 3

8 MAY '74





ELECTRONIC ~~SIMULATED~~ BEARING RESULTS

AMF MODEL 301 RECEIVER

CHANNEL 1	TRANSFER CHART	STARBOARD METER
52 μs	3.6°	0°
54.5 μs	7.5°	5°
57.6 μs	13°	10°
60.4 μs	17.8°	15°
63.5 μs	23.7°	20°
66 μs	28°	25°
68.3 μs	32.2°	30°
70.7 μs	36.8°	35°
72.9 μs	41°	40°
74.8 μs	44.3°	45°
77.1 μs	48.2°	50°
78.9 μs	51.5°	55°
80.7 μs	54.5	60°
82.9 μs	59°	75°
85.5 μs	63.5°	90°

↑ PHASE SHIFT

↑ METER SHOULD INDICATE

↑ ACTUAL METER READING

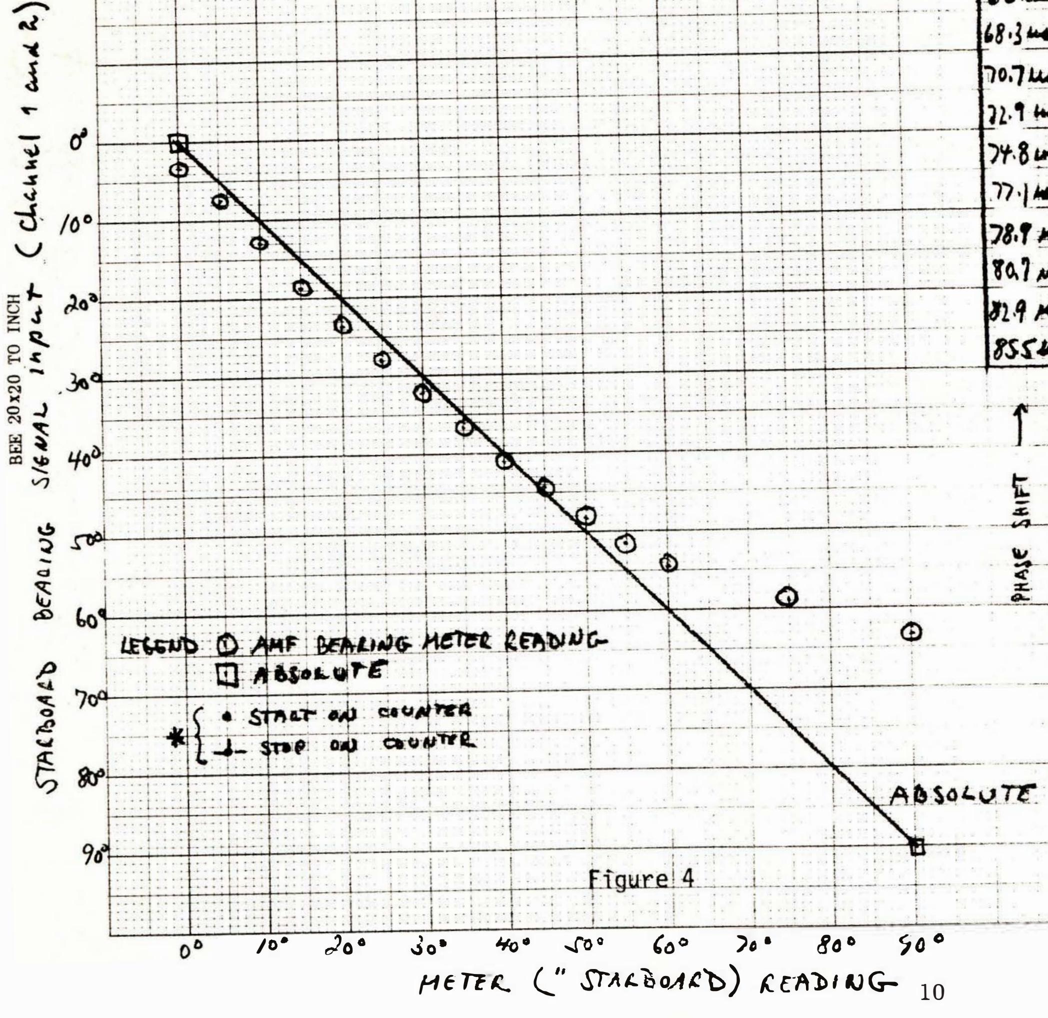
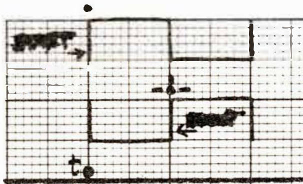


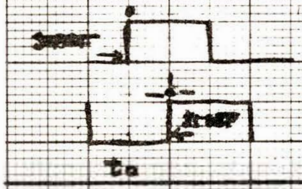
Figure 4

7 MAY '74



Channel 1 Bearing 0° PORT

Channel 2 Reference (on oscilloscope)



Channel 1 Bearing 45° PORT

Channel 2 Reference (on oscilloscope)

ELECTRONIC SIMULATED BEARING RESULTS

AMF MODEL 201 RECEIVER

CHANNEL 1	TRANSFER CHART	PORT METER
52 us	53.6°	0°
47.5 us	4°	5°
44.5 us	9.5°	10°
41.3 us	15°	15°
38 us	21°	20°
35 us	26.5°	25°
32.3 us	31°	30°
29 us	37.5°	35°
26.8 us	41.2°	40°
24.3 us	45.5°	45°
22.2 us	49.8°	50°
20.5 us	51.5°	55°
19.1 us	55.2°	60°
15.7 us	61.5°	75°
13.7 us	65.2°	90°

PHASE SHIFT ↑ | METER SHOULD INDICATE ↑ | ACTUAL METER READING ↑

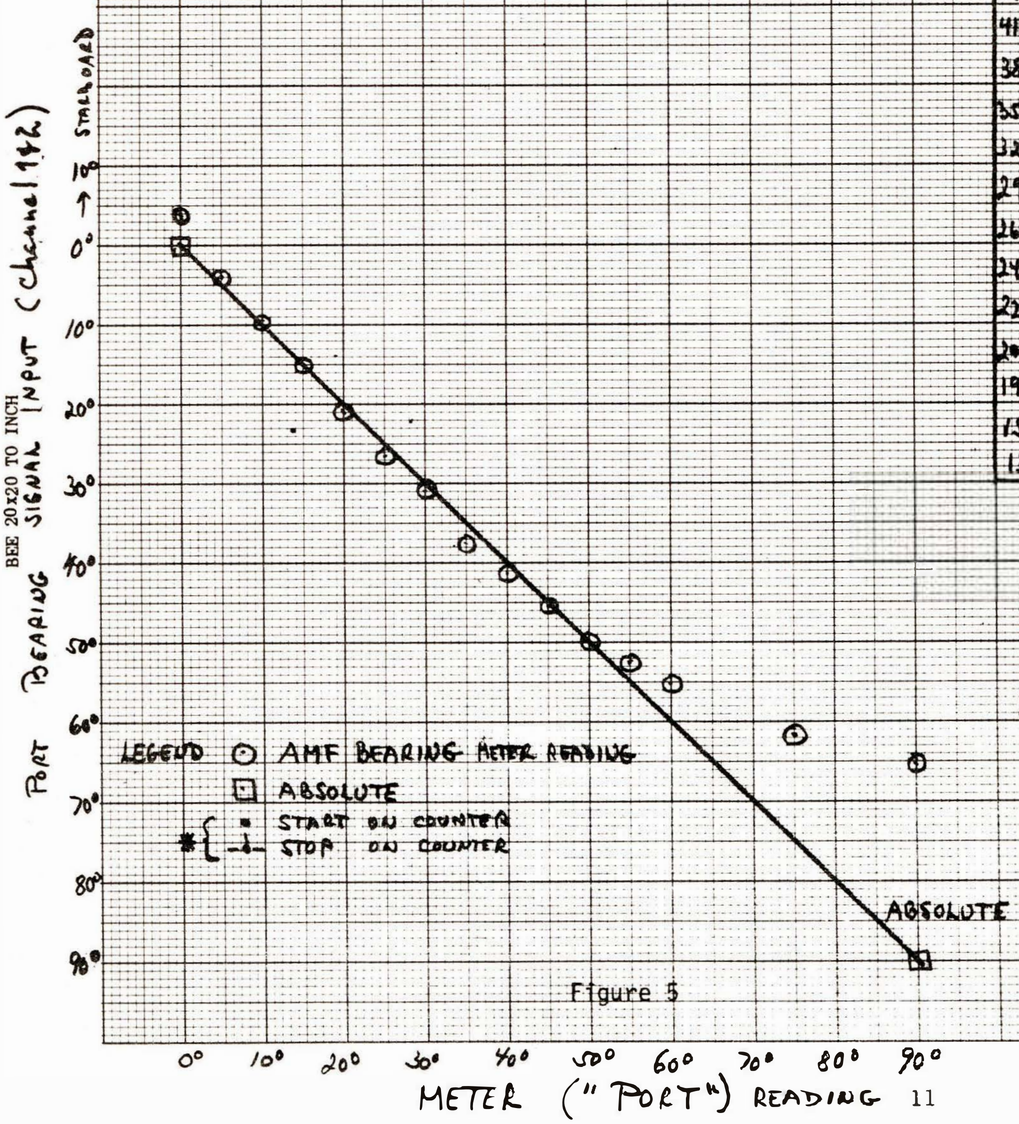


Figure 5

Timing Accuracy

	Input Signal-to-Noise Ratio	Probability of detection
±0.23 msec at 3σ limits	15.8 dB	100%
±57.4 msec at 3σ limits[6]	12.5 dB	greater than 99%

[7]PERFORMANCE TESTS - MODEL 322 RECOVERABLE ACOUSTIC TRANSPONDER

Pinger/Transponder	
Operating frequency	Within specifications (both units)
Pulse width	Within specifications (both units)
Mean source pressure level, x axis (360°), normal to acoustic axis	
SN 331	88.75 dB (omnidirectional ±1.45 dB)
SN 332	88.95 dB (omnidirectional ±1.25 dB)
Mean source pressure level, Y axis (180°), upper hemisphere	
SN 331	92.6 dB ±4 dB (See Figure 6)
SN 332	91.1 dB ±4.5 dB (See Figure 7)
Nominal Pinger Pulse Rate	1 pulse each 2 sec (Command 2 reply) 1 pulse each 1 sec (Command 3 reply) 1 pulse each command (Transponder)
Receiver Characteristics	
SN 331 (Command 2)	-2.6 dB re 1 microbar (See Figure 8)
SN 332 (Command 2)	-11.3 dB re 1 microbar (See Figure 9)
SN 331 (Transponder, 100% operation)	0 dB re 1 microbar
SN 332 (Transponder, 100% operation)	-7.7 dB re 1 microbar

---

[6] Timing Stability was determined with a simulated return signal for 1,000 samples using Hewlett Packard Computing Counter Application Library, Program No. 13, Time Interval Jitter (RMS), March 1970.

[7] Two transponders were tested: serial numbers 331 and 332.

Refer Pg 13

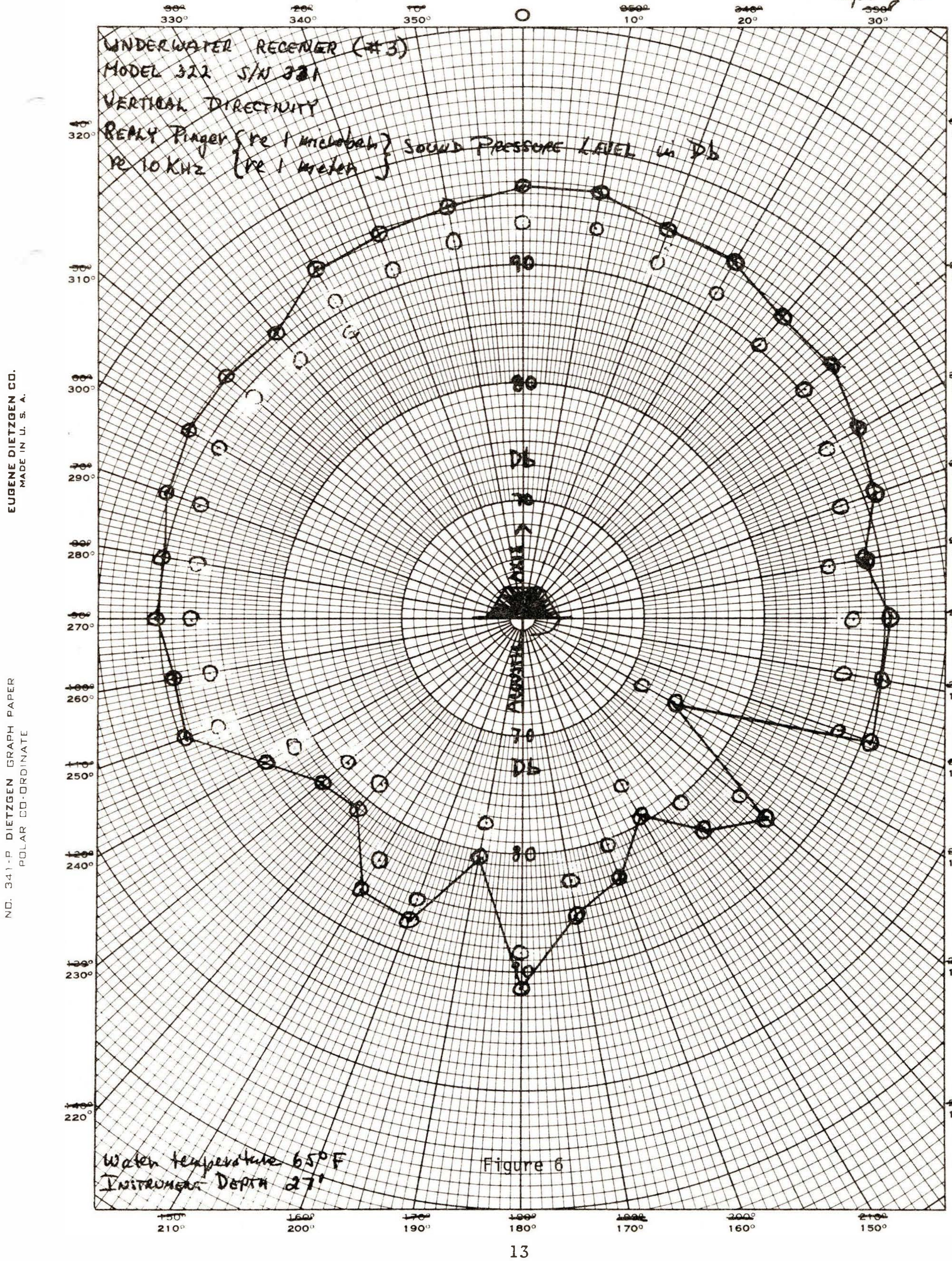


Figure 6

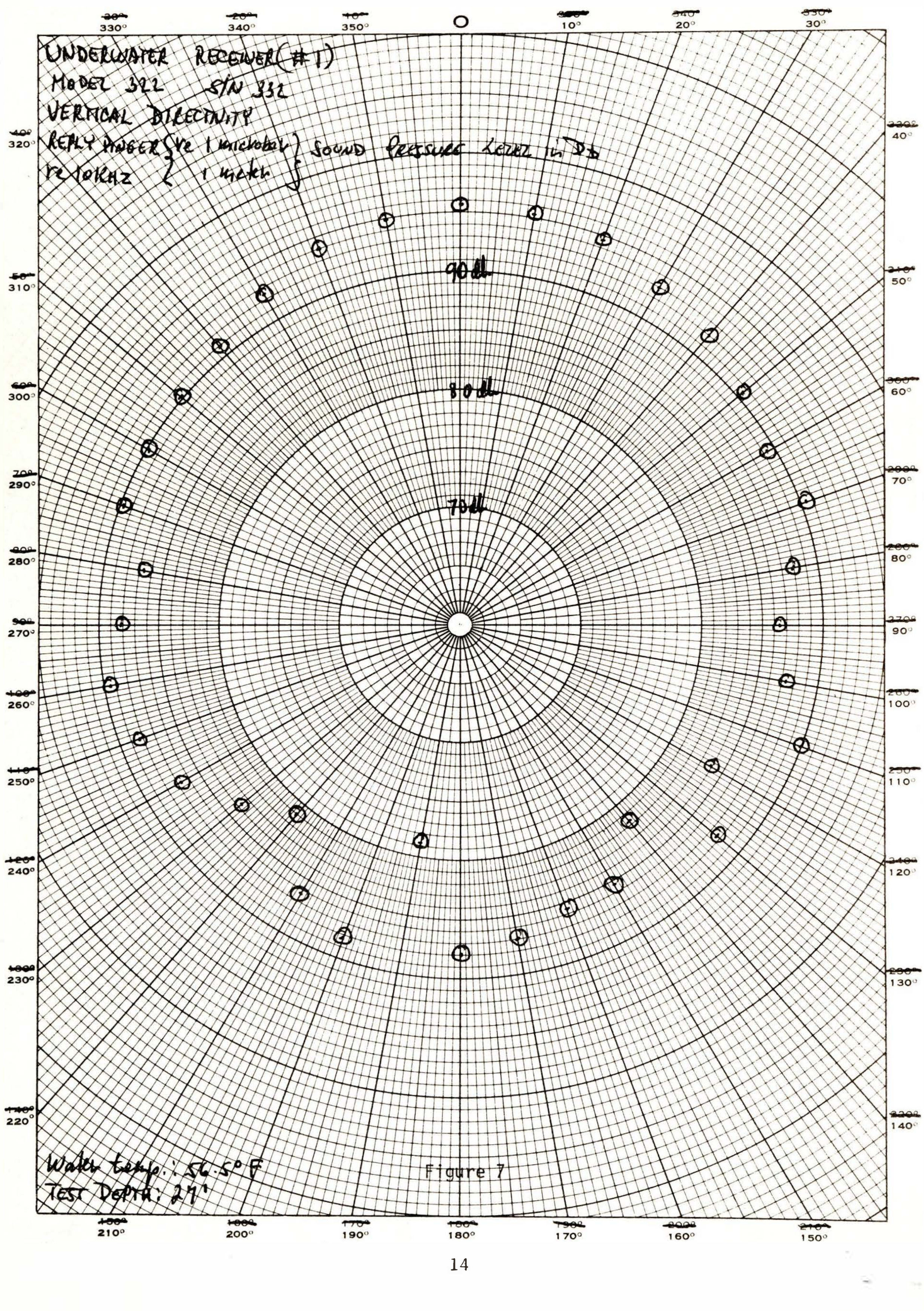
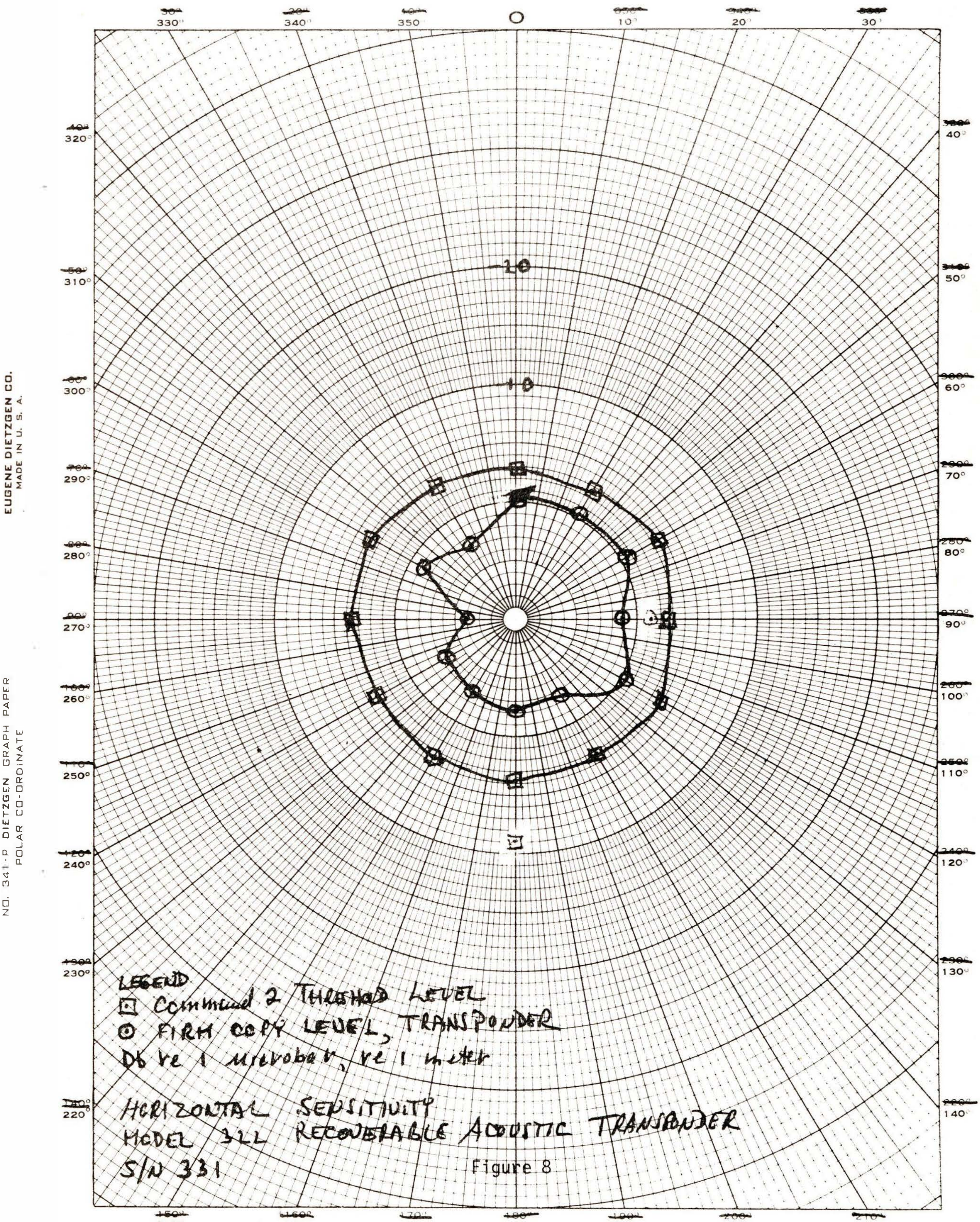
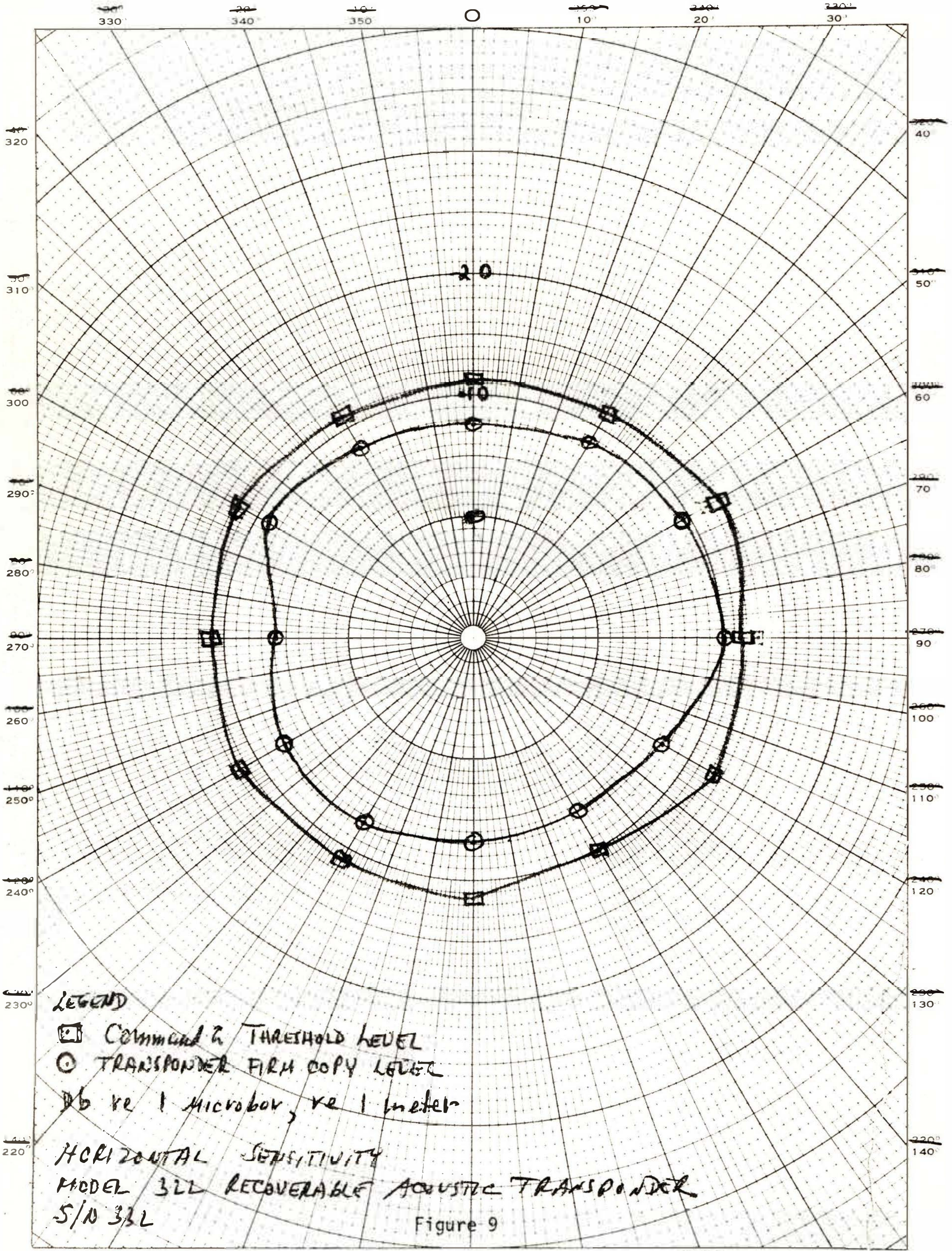

UNDERWATER RECEIVER (#1)
MODEL 322 S/N 332
VERTICAL DIRECTIVITY
REPLY PINGER {re 1 microbar} SOUND PRESSURE LEVEL in DB
re 10KHZ { 1 meter}
90 db
80 db
70 db
Water temp.: 56.5° F
TEST DEPTH: 27'
0
10°
20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
210°
220°
230°
240°
250°
260°
270°
280°
290°
300°
310°
320°
330°
340°
350°

Figure 7



HORIZONTAL SENSITIVITY
MODEL 322 RECOVERABLE ACOUSTIC TRANSPONDER
S/N 331

Figure 8



LEGEND
⊡ Command & THRESHOLD LEVEL
⊙ TRANSPONDER FIRM COPY LEVEL
Db re 1 microbar, re 1 meter

HORIZONTAL SENSITIVITY
MODEL 322 RECOVERABLE ACOUSTIC TRANSPONDER
S/N 322

Figure 9

Release Characteristics	Performed within specifications

Reply Pinger - 24 hours sequential operation (S/N 331 only)

Battery performance degrades rather rapidly in the first few minutes of operation. Relative stability in the energy output occurs within 5 minutes. Additionally, the reply burst exhibits droop characteristics; the acoustic output (dB) decreases during the duration of reply (see page 18). A zinc-carbon 45-volt transmitter battery was used for these tests.

Humidity (MIL-E-16400 F, Paragraph 4.5.9)	No observable effect
Salt Spray (MIL-STD-202C, Method 101B)	No observable effects

A February, 1975 recovery attempt of both acoustic release moorings deployed during field tests in July 1974 was not successful.

C. Future Plans

In addition to the Instrument Fact Sheet, a Technical Bulletin will be written summarizing the field test results.

MARINE RESOURCES MODEL 096R DEEP SEA ACOUSTIC RELEASE TRANSPONDER

A. Description

The transponder consists of a pressure housing with outboard transducer and activation magnet and in-board electronics and battery pack. In the Interrogation Mode, the unit responds to a 13 kHz-10 msec pulse and replies with a 13 kHz-15 msec pulse. Instead of 13 kHz, the receiver frequency can be specified as 11, 11.5 or 12.5 kHz. The release mode is activated by modulating the interrogation frequency with a square wave (100% modulation) and 50% duty cycle. The square wave modulation rate is 136.5 Hz but can also be specified at 123.0 Hz or 151.4 Hz. When the release command is received, an electrical potential is applied to the trip-wire holding a double arm, captive-link release mechanism. The potential produces electrolytic deposition of the trip wire onto a return cathode and after approximately 3.5 minutes the wire is etched away, freeing the arms and link to which the anchor line is attached. During the period while the trip-wire is under electrolytic decomposition, the unit will reply to interrogation with a double pulse (0.5 sec spacing).

	-5°C		0°C		10°C		20°C		30°C		50°C	
	Db		Db		Db		Db		Db		Db	
	Max.	Droop	Max.	Droop	Max.	Droop	Max.	Droop	Max.	Droop	Max.	Droop
Initial wavetrain burst	0	-4.3	0	-5	0	-2.7	0	-2.8	0	-1.6	0	-1.2
5 minutes operation	-5.1	-6.7	-5.6	-6.9	-4.9	-6.5	-4.2	-6.4	-3.5	-5.7	-4.5	-5.8
24 hours operation	-6.5	-7.8	-6.2	-7.6	-5.5	-7.3	-5.7	-7.1	-4.4	-6.8	-4.8	-6.6
Nominal Frequency	10030 Hz		10037 Hz		10020 Hz		10015 Hz		10005 Hz		9977 Hz	
Nominal burst rate	One per 1.012s		One per 1.016s		One per 1.030s		One per 1.040s		One per 1.05s		One per 1.056s	
Nominal burst length	18 ms		18.2 ms		18.2 ms		18.4 ms		18.8 ms		19.2 ms	
Nominal burst count	51 per min.		52 per min.		52 per min.		48 per min.		48 per min.		51 per min.	

B. Progress

The evaluation of this release is 90% complete. During the evaluation, it was noted that if the release link was inclined at certain angles to the end plate, the release linkage would not open after the trip wire was released. A fixture is being designed to measure the inclination angle of the release link to the end plate with the specified tension applied. This test and the vibration test will conclude the evaluation of the Marine Resources unit.

C. Future Plans

The laboratory evaluation for the Model 096R Deep Sea Acoustic Release Transponder (S/N 1) is scheduled to be completed in August 1975. In addition to the Instrument Fact Sheet, a Technical Bulletin will be written summarizing the field test intercomparison results of the Marine Resources and the AMF acoustic release systems.

KLEIN ASSOCIATES SIDE SCAN SONAR (MODEL 400)

A. Description

The Model 400 Side Scan Sonar System consists of a dual channel recorder subsystem that displays both channels of bottom data and a towing subsystem comprising a towfish containing the transducers and electronics, a recovery device and a depressor. The towed underwater unit sends out pulsed, high frequency signals that are beamed to either side of the fish perpendicular to the direction of travel. The transducer beam patterns are narrow in the horizontal and wide in the vertical plane to optimize insonification of the ocean bottom. On either side of the towfish, the key pulses from the recorder control the transmission of acoustic signals in the towfish, and the return signals are processed in the recorder resulting in a permanent strip-chart recording of both channels. The recovery device prevents the towfish from hitting the bottom when the survey vessel is stopped and raises the towfish and depressor to the surface if the towline is severed. The depressor compensates for the increased cable drag as the survey vessel speed is increased by maintaining the depth of the towfish constant. Applications for the side scan sonar include geologic and sand ripple study, bathymetry and hydrography, mineral search, cable and pipeline location, engineering surveys, and underwater archeology.

B. Progress

A Model 400 system is scheduled to be transferred from NAVOCEANO (Code 3551) to NOIC in September 1975. The general test plan for the recorder subsystem is enclosed as Appendix A. In addition, a complete acoustic calibration of the towed unit and acoustic target resolution tests for the system are planned at the Naval Surface Weapons Center, Brighton Dam facility.

C. Future Plans

The evaluation is scheduled to start in September 1975 and be completed in May 1976. An Instrument Fact Sheet will be written summarizing the laboratory tests.

RAYTHEON MODEL UGR-196C UNIVERSAL GRAPHIC RECORDER

A. Description

The Raytheon Universal Recorder (Model UGR-196C) is a general purpose, line scan recorder designed for multiapplication recording needs. A few of the possible applications of the UGR are echo sounding, seismic profiling, facsimile, spectrum analysis, and the display of computer generated data.

The UGR is constructed to permit installation on either table top or bulkhead. The main frame mounts via three bolts through the recorder base with the rubber feet acting as dampers at the four corners. Access to the three bolt holes can be gained by removing the recorder platen, the front grill, and the air filter cover located beneath and behind the recording paper feed roll.

The recording medium is dry electrosensitive paper (Timefax NDK). The paper roll size is 19 1/8 in. (48.58 cm) x 120 ft. (36.58 m) with an active scan length of 18.85 in. (47.88 cm). The viewing area is the full chart width x 12-in. (30.48 cm) long including first printed line. Grid lines are switch selectable: 10 or 20 divisions across chart. Line densities are switch selectable: 160, 128, 80, 64, and 40 lines per in. (approximately 63, 50.4, 31.5, 25.2, 15.75 lines per cm).

The scan mechanism is a synchronous motor driving a belt with three equally-spaced styli. The sweep drive is derived internally from a 38.4-kHz oscillator thereby making the motor drive frequency somewhat independent of power line variation. A motor frequency reference can also be supplied from an external source. The scan speeds are switch selectable at 1/4, 1/2, 1, 2, 5, and 10 s per scan with optional speeds available (1/8 s per scan maximum). The normal scan direction is from left to right with a factory installed right-to-left scan option. Paper drive is also developed from the same basic 38.4-kHz clock.

The UGR evaluated was supplied with the following options:

Programmer to eliminate echo confusion and data loss

Single-sweep Function for start/stop syncronization with seismic sources

Delayed Sweep for expanding scale and eliminating the water column

End of Paper Switch

Elapsed Time Meter.

B. Progress

The evaluation was completed in January 1975. A summary of the evaluation tests follows:

PERFORMANCE TESTS[1,2]

INPUT IMPEDANCE ($|Zi|$)

The following data are magnitudes of the recorder input Zi for various gain settings at a frequency of 10 kHz:

GAIN setting	$\|Zi\|$ (kohm)
Minimum (fully ccw)	9.8
Mid-range	7.6
Maximum (fully cw)	5.0

BANDWIDTH

The recorder prints all signals with frequencies up to 100 kHz[3].

SELF NOISE

The recorder input terminals were shorted to ground and the print preamplifier output voltage was recorded as a function of sweep speed.

---

[1] See General Comment #1

[2] See General Comment #2

[3] See General Comment #3

Sweep speed (s/scan)	Self-noise voltage (mV rms)
10	3.9
5	3.9
2	4.5
1	4.7
1/2	5.5
1/4	12.4

MINIMUM DETECTABLE LEVEL (MDL)

A simulated return signal (a 12-kHz tone burst of 1 ms duration) was fed to the recorder input to determine the minimum input signal voltage necessary for display on the recorder. The UGR control settings were:

GAIN = maximum

THRESHOLD = minimum

CONTRAST[4] = maximum

Sweep speed (s/scan)	Line density (lines/in.)	MDL (mV rms)
1	160	32
1/2	160	35
1/4	160	32
1	80	44
1/4	80	41
1/4	40	44

SIGNAL-TO-NOISE RATIO

The simulated return signal was summed with a Gaussian noise signal of 97 mV rms and applied to the recorder input. The purpose of this test was to determine the minimum signal-to-noise ratio (S/N) required to detect the simulated return signal on the recorder display.

[4] See General Comment #4

Sweep speed (s/scan)	Minimum signal (mV rms)	S/N
1/4	0.03	0.31 (-10 dB)
1	0.60	0.62 (-4 dB)
5	1.20	1.24 (+2 dB)

DYNAMIC RANGE

To determine the dynamic range, the input noise voltage was increased until saturation (no discernible difference in succeeding displays) was reached. This noise voltage was then used to determine the dynamic range.

$$\text{Dynamic Range} = 20 \log\left(\frac{\text{Saturation Noise Voltage}}{\text{MDL}}\right)$$

Sweep speed (s/scan)	Dynamic range (dB)
1/4	21
1	25
5	25

TIME BASE STABILITY[5] (short-term)

Two thousand test samples of the 38.4-kHz internal clock frequency were taken at various averaging times (the counter's measurement time for each frequency sample) and the short-term stability computed using the formula[6]:

$$\left\langle \sigma_2 \left(\frac{\Delta f}{f_o}\right) \right\rangle = \frac{1}{f_o}\sqrt{\frac{1}{2N}\sum_{i=1}^{N}(f_{2i} - f_{2i-1})^2}$$

Averaging time (ms)	$\left\langle \sigma_2 \left(\frac{\Delta f}{f_o}\right) \right\rangle$ (ppm)
100	1.445
500	0.552
1,000	0.512

---

[5] See General Comment #5

[6] See General Comment #6

TIME BASE STABILITY[5] (long-term)

The 38.4-kHz internal clock was compared with a cesium beam standard with a stability of $\pm 1 \times 10^{-11}$. Over a seven-hour test period, the 38.4-kHz clock indicated a stability of ±4 ppm.

CHART SPEED

The chart speed of the recorder was measured at various combinations of scan speed, line density, and paper tension and found to be within ±4 ppt.

POWER SUPPLY EFFECTS

The recorder operated satisfactorily when the line voltage and frequency were varied from 100 to 130 V ac and 50 to 60 Hz, respectively. For the worst case condition of 95 V ac and 55 Hz, there were oscillations in the grid lines and return signal. This problem did not exist at 50 and 60 Hz at 95 V ac.

POWER CONSUMPTION

With the PRINT RESPONSE in the "+" position, the average power consumption was:

260 watts grid line printing

ENVIRONMENTAL TESTS

TEMPERATURE

The recorder operated satisfactorily between 0°C and +50°C.

HUMIDITY

The recorder operated satisfactorily between 20% RH and 96% RH at 25°C.

VIBRATION

The UGR was evaluated in accordance with MIL-STD-167B (Aug. 11, 1969), Type I. The recorder was operated at a sweep speed of 2 s/scan and a GAIN setting of 3/4 maximum. A simulated return signal was applied to the input and the programmer was used during all vibration tests.

Direction: normal to sides

During the exploratory investigation, the programmer developed an erratic counting sequence. This problem was traced to an intermittent connection in the ac power cord connector. The manufacturer replaced the power cord and the problem was alleviated. During the 5- to 33-Hz variable frequency test, the recorder paper advance went into a runaway mode. This problem was solved by reducing the paper tension to one-half.

Direction: normal to recorder display

The recorder operated satisfactorily through the variable frequency test and one hour and 50 minutes into the two-hour endurance test. At that time, the programmer again developed an erratic count behavior. A manufacturer's representative traced the problem to a loose pin in the drive motor connector and a frayed wire in the electromechanical pulse generator of the Edge-Center key card.

Direction: front to back

The programmer again developed its erratic behavior at 21 Hz of the variable frequency test. This problem persisted through 25 Hz and disappeared at 26 Hz. This erratic behavior reappeared again at an aperiodic rate and 10% duty cycle during the two-hour endurance test.

GENERAL COMMENTS

1. Unless otherwise noted, all test values are worst case.

2. Unless otherwise noted, all control settings are as given in the "INITIAL CONTROL SETTINGS" of the technical manual.

3. The bandwidth of the low pass filter located in the print preamplifier was measured to be 8 kHz. This filter and the full-wave rectifier of the preceding stage form the envelope detector of the recorder. The input operational amplifier of the print preamplifier has a bandwidth greater than 100 kHz as specified by the manufacturer.

4. The CONTRAST control was wired in reverse from that specified in the manual for the UGR evaluated (S/N 102).

5. Time-base stabilities were evaluated only after a minimum warm-up time of 30 minutes.

6. "Fractional Frequency Deviation (Short-term Stability of Oscillators)" Computing Counter Applications Library, No. 7 (Hewlett Packard; 1970).

7. During the preliminary check-out, it was noted that the external signal required in the start-stop mode was +3 volts. As the specifications state that the minimum signal required is +2 volts, the

manufacturer replaced the Generator Start/Stop card (A8) and solved this problem.

8. In a letter dated May 29, 1975, the manufacturer made the following comment about the results of the vibration test, "In order to have the UGR comply fully with its environmental requirements, the programmer, which is an optional plug-in card, will be structurally modified."

INNERSPACE TECHNOLOGY MODEL 410 DIGITAL DEPTH TRACKER

A. Description

The Model 410 Digitizer provides an accurate four-digit visual display of water depth in feet or fathoms (meters optional) when interfaced with survey type echo sounders. A binary-coded decimal (BCD) output of depth information is provided for recording on magnetic tape, paper tape or digital printer. The unit displays a depth range from 2.0 - 999.9 with a timing accuracy of ±0.1 which is maintained by a precision crystal oscillator and is independent of the echo sounder's mechanical timing. The digitizer may be operated in a direct mode in which the first return after the outgoing transmission is digitized. In the range-gated mode, a gate is digitally positioned symmetrically about the bottom and tracks the bottom automatically. The gate width can be manually selected from six different widths and eliminates the possibility of tracking mid-water false replies. In the auto mode, the digitizer will track a reply within the range gate; however, if the bottom should change faster than the width of the range gate, the digitizer will automatically switch to the direct mode and reacquire the bottom after a selected number of missed replies.

B. Progress

The Model 410 with the three other digital depth trackers shown on the Acoustics Project Testing Program Chart have been transferred from NAVOCEANO to NOIC. Gradient simulation circuitry has been designed to evaluate tracker performance at different gradients and signal-to-noise ratios.

To process the digital tracker data, the H-P computing counter will be programmed to calculate the average gradient generated during each down and up slope and compare the tracker output with the simulated gradient on a point-by-point basis.

The general test plan for digital trackers is enclosed as Appendix B.

C. Future Plans

The evaluation of the Model 410 is scheduled to start in August 1975 and be completed in January 1976. An Instrument Fact Sheet will be written summarizing the laboratory tests. A joint NOIC/NAVOCEANO field test is tentatively planned for all digital depth trackers in the evaluation program, and a report will be written summarizing the field test results.

CONDUCTIVITY/SALINITY-TEMPERATURE-DEPTH MEASURING SYSTEMS (C/STDs)

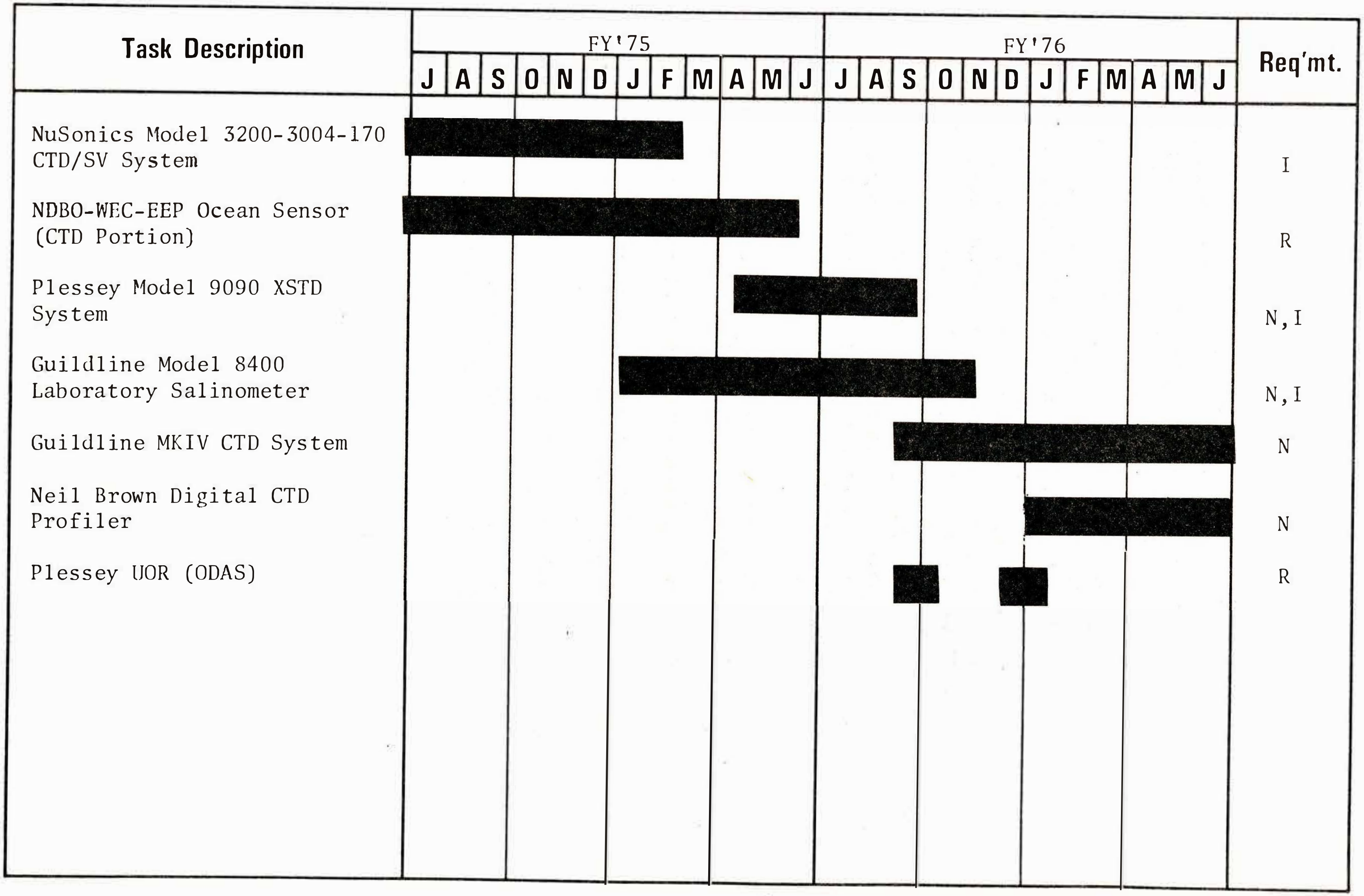
TESTING PROGRAM

Date: July 1, 1975

Project: C/STD

Project Leader: J. Boyd

N — Navy
I — In-House
R — Reimbursable
O — Other



Task Description	Req'mt.
NuSonics Model 3200-3004-170 CTD/SV System	I
NDBO-WEC-EEP Ocean Sensor (CTD Portion)	R
Plessey Model 9090 XSTD System	N,I
Guildline Model 8400 Laboratory Salinometer	N,I
Guildline MKIV CTD System	N
Neil Brown Digital CTD Profiler	N
Plessey UOR (ODAS)	R

NUSONICS MODEL 3200-3004-170 CONDUCTIVITY-TEMPERATURE-DEPTH-SOUND VELOCITY SYSTEM

A. Description

The NuSonics Model 3200-3004-170 CTD-SV System is designed to measure, telemeter, and condition ocean variables of seawater conductivity, temperature, depth (pressure), and sound speed. The system consists of an underwater unit (NuSonics Model 1641-169) and shipboard signal converter. Two separate pressure housings make up the underwater unit with each containing transducers (sensors) and conditioning electronics for transmission of data to the shipboard signal converter for each of the variables being measured. Temperature is sensed with a platinum-wire resistance thermometer, conductivity with an inductively-coupled toroidal cell, pressure with a resistance strain-gauge bridge, and sound speed with acoustic transducers employed in a sing-around sound path. The sensed variables are converted to FM data signals, frequency multiplexed, and transmitted to the signal converter by a single electrical conductor. DC power is transmitted to the underwater unit via another conductor, thus the electrical sea cable requiring two separate electrical conductors with the armor carrying the signal and power returns.

The shipboard signal converter provides the following functions and are listed below in the approximate sequence of their occurrence:

1. The FM multiplexed sensor signal is amplified.

2. The FM multiplexed sensor signal is separated into four separate data signals (frequency).

3. Each frequency is amplified.

4. Each frequency is converted from sinewave to square wave and multiplied to a condition that is compatible with its respective Scaled D-A converter.

5. Each frequency is converted to a 0-10 VDC analog signal which is available over a wide sensor measurement range or narrow overlapping ranges depending on a switch setting.

B. Progress

The remaining 5% of the test work was completed to conclude the total laboratory test and evaluation on this system. The work included data analysis of data-channel noise measurements on the shipboard signal converter and long-term stability tests on the sound velocity and pressure sensing channels. A summary of all test results will be published in NOIC Instrument Fact Sheet 76002.

C. Future Plans

None.

WESTINGHOUSE ELECTRIC CORPORATION/NOAA DATA BUOY OFFICE OCEAN SENSOR

A. Description

The Westinghouse Electric Corporation (WEC) Ocean Sensor (OS) was developed for the NOAA Data Buoy Office's Engineering Experimental Phase. The OS is mounted on a data buoy hull or to a mooring line at various depths. The OS consists of a pressure housing, electronics, and transducers. The sensor, after interrogation from a Sensor Deck Unit (SDU),converts oceanographic environmental measurements into telemetering signals that are transmitted through the SDU to an Ocean Platform System. The OS contains the electronics and transducers required to obtain measurements for conductivity, temperature, and pressure.

B. Progress

Computer reduction and analysis of all test data were completed and a preliminary test report was written. Table I shows measurement performance test results for the three sensing channels, i.e., temperature, conductivity, and pressure; also shown is the equivalent error in computed salinity from temperature, conductivity, and pressure due to inaccuracies associated with each variable.

C. Future Plans

Finish test report and disseminate in the form of a NOAA Technical Memorandum.

PLESSEY MODEL 9090 EXPENDABLE SALINITY-TEMPERATURE-DEPTH SYSTEM (XSTD)

A. Description

The Model 9090 XSTD System is designed to obtain economical Temperature and Salinity or Sound Velocity profiles from the ocean environment. The system consists of inexpensive expendable probes that measure conductivity and temperature and simultaneously transmit this data over a wire link to shipboard processing equipment that provides real time output functions of conductivity, temperature, and cast duration for digital binary magnetic recording. The processor also provides computed

Table I

WEC Ocean Sensor
Test Results Summary
S/N 023

OS Channel / Performance Parameter		Temperature (°C)	Conductivity (mho x 10^{-3}/cm)	Pressure (decibars)	Equivalent Error in Computed Salinity From T, C, & P (ppt)
Nonrepeatability		±0.010	±0.179	±1.43	±0.179
Nonlinearity		±0.005	±0.014	±0.02	±0.015
Temperature Effect (±20°C)		Combined with nonlinearity	≃0.009 mho x 10^{-3}/ C° (±0.184)	≃-0.191 decibars/°C (±3.8)	±0.184
Stability		±0.012 (8 months)	Not Tested	Not Tested	
Overange Effects		Within Nonrepeatability	±0.224	±1.26	
Slope	WEC	0.01°C/count	0.015 mmho/cm/ count	1.2258 decibars/ count	
	NOIC (Error FR)	0.0099963°C/ count (±0.008)	0.014902 mmho/cm/ count (±0.201)	1.2253 decibars/ count (±0.13)	
Inaccuracy (RSS) (Design, Acceptable Goals)		±0.016 (±0.01, ±0.06)	±0.257 (±0.015, ?)	±4.06 (±2.4, ±4.9)	±0.258 (±0.01, ±0.03)
Inaccuracy (RSS) With Temperature Corrections Applied		±0.016	±0.180	±1.43	±0.181

$\frac{\partial S}{\partial T} = \frac{\partial S}{\partial G} = 1000 \frac{\partial S}{\partial P} = 1$ where S is salinity (ppt)
T is temperature (°C)
G is conductivity (mho x 10^{-3}/cm)
P is pressure (decibars)

salinity or sound velocity and temperature as a function of depth for analog graphic recording.

The probe is designed for operation to depths of 750 meters over temperature and salinity range of -2 → 35°C and 30 → 40 ppt. It can be deployed from existing, hand-held, deck-mounted, or through-hull launchers, since it is mechanically interchangeable with the Expendable Bathythermograph (XBT).

In addition to the processor, the shipboard equipment also includes an analog multipen recorder and an optional incremental, digital magnetic tape cassette recorder. Information stored on tape is processed through a tape processor which can be purchased as peripheral equipment with the XSTD System. The company also offers a tape-processing service by mail.

B. Progress

Electronic and functional checks were completed on the shipboard processor. The various functional checks performed are listed below.

1. Frequency-to-count conversion - Processor converts the temperature and conductivity sensor frequencies (212.7 → 402.5 Hz for temperature and 499.5 → 800.7 Hz for conductivity) to a binary count ranging from 0000 → 4095_{10} and 2540 → 4095_{10}, respectively.

2. Depth time generator - At the instant an XSTD probe contacts seawater, the processor detects a load change in the sensor's power supply and enables a binary counter to count a fixed frequency. After 128.6 ±2 seconds, the counter should stop (generate system reset) and display a count of 4088_{10}.

3. Temperature and Pressure Count to analog conversion - The temperature and pressure binary counter outputs drive 12 bit D → A converters resulting in an analog output of 0 → 10 mV for the full counter range (0000 → 4095). The conductivity counter output is also converted to analog, but it's not furnished as an output.

4. Analog computer derived salinity and sound velocity - Depending on how the processor is programmed (via plug-in modules), the analogs of C, T, & P are used to drive an analog computer to derive an analog signal (0 - 10 mV) of salinity or sound velocity representing 30 → 40 ppt and 1400 → 1600 M/s, respectively.

5. Plotter drive - 0 - 10 mV on all inputs give corresponding 0 → FS on all parameter scales.

A special test fixture was developed to perform a go - no/go type test on XSTD probes (26 count). The fixture allows the probes to be easily powered and the conductivity cell to be partially filled with a salt water sample to kick off the conductivity oscillator. With this technique, a coarse calibration on temperature and conductivity measurements can be performed on all probes. Also, while the probes are in the fixture, electrical checks of probe power voltage and current and output signal amplitude are being performed.

All tests performed thus far indicate the system is performing reasonably close to the manufacturer's stated specifications (accuracy specifications are specified on a statistical basis).

Two electronic failures have occurred thus far; a solid voltage regulator (+15 VDC) on power supply board and a quad-two input NOR gate on the control board have fiiled.

C. Future Plans

Complete XSTD probe tests. Field test system aboard NOAA ship, MT. MITCHELL, in August or September 1975.

GUILDLINE LABORATORY SALINOMETER MODEL 8400

A. Description

This instrument is designed for laboratory use which measures and displays the conductivity ratio of an unknown water sample with respect to standard Copenhagen water. A square wave potential comparator technique is used to continuously compare the resistance of a cell filled with a sample salinity solution at constant known temperature with an integral reference resistor initially adjusted to the cell resistance when filled with standard water at the same temperature. A four-electrode conductivity cell is used to sense the conductance. Readout is both digital display and BCD output.

B. Progress

About 80% of the planned laboratory tests were completed; they were as listed below.

1. An overall 24-hour temperature stability test was performed on bath temperature settings. Table II is a summary of the test results; worst case was ±0.004°C (specification ±0.001°C per day).

2. Power line voltage and frequency variation test, 50 → 60 Hz @ 102 → 129 VAC. The bath temperature and conductivity ratio measurements were not affected by the test variations.

3. Conductivity ratio measurement accuracy test - Figure 10 shows

TABLE II

GUILDLINE MODEL 8400 AUTOSAL

TEMP. °C INSTRUMENT BATH TEMPERATURE STABILITY TEST

Inst. Set Pt.	Chamber + -0.3	Mean n/60	Error	Error b-a	Mean a+b/2	Mean Error	12 Hour Stability	Over-All * Stability	Gain Ref Number	Gain Ref b-a	Zero	Zero b-a
18	1a 14	17.9515	+0.0485				±0.0010		18+6921		0.0+0008	
	1b 20	17.9541	+0.0459	-0.0026	17.9528	+0.0472	±0.0011	±0.0024	18+6921	0	0.0+0004	-0.00004
21	2a 17	20.9667	+0.0333				±0.0008		21+7329		0.0+0006	
	2b 23	20.9679	+0.0321	-0.0012	20.9673	+0.0327	±0.0011	±0.0016	21+7329	0	0.0+0002	-0.00004
24	3a 20	23.9703	+0.0297				±0.0010		24+7775		0.0+0004	
	3b 26	23.9720	+0.0280	-0.0017	23.9712	+0.0288	±0.0012	±0.0020	24+7775	0	0.0+0000	-0.00004
27	4a 23	26.9749	+0.0251				±0.0010		27+8190		0.0+0002	
	4b 29	26.9770	+0.0230	-0.0021	26.9725	+0.0275	±0.0010	±0.0021	27+8191	+1	0.0-0001	-0.00003
30	5a 26	29.9783	+0.0217				±0.0011		30+8614		0.0+0000	
	5b 32	29.9807	+0.0193	-0.0024	29.9795	+0.0205	±0.0045	±0.0040	30+8615	+1	0.0-0004	-0.00004
33	6a 29	32.9905	+0.0095				±0.0035		33+9044		0.0-0002	
	6b 35	32.9932	+0.0068	-0.0027	32.9919	+0.0082	+0.0012	+0.0037	33+9044	0	0.0-0006	-0.00004

*Over-all stability is the Total spread of the bath fluctuations from the beginning of a to the end of b
Total 24 hours

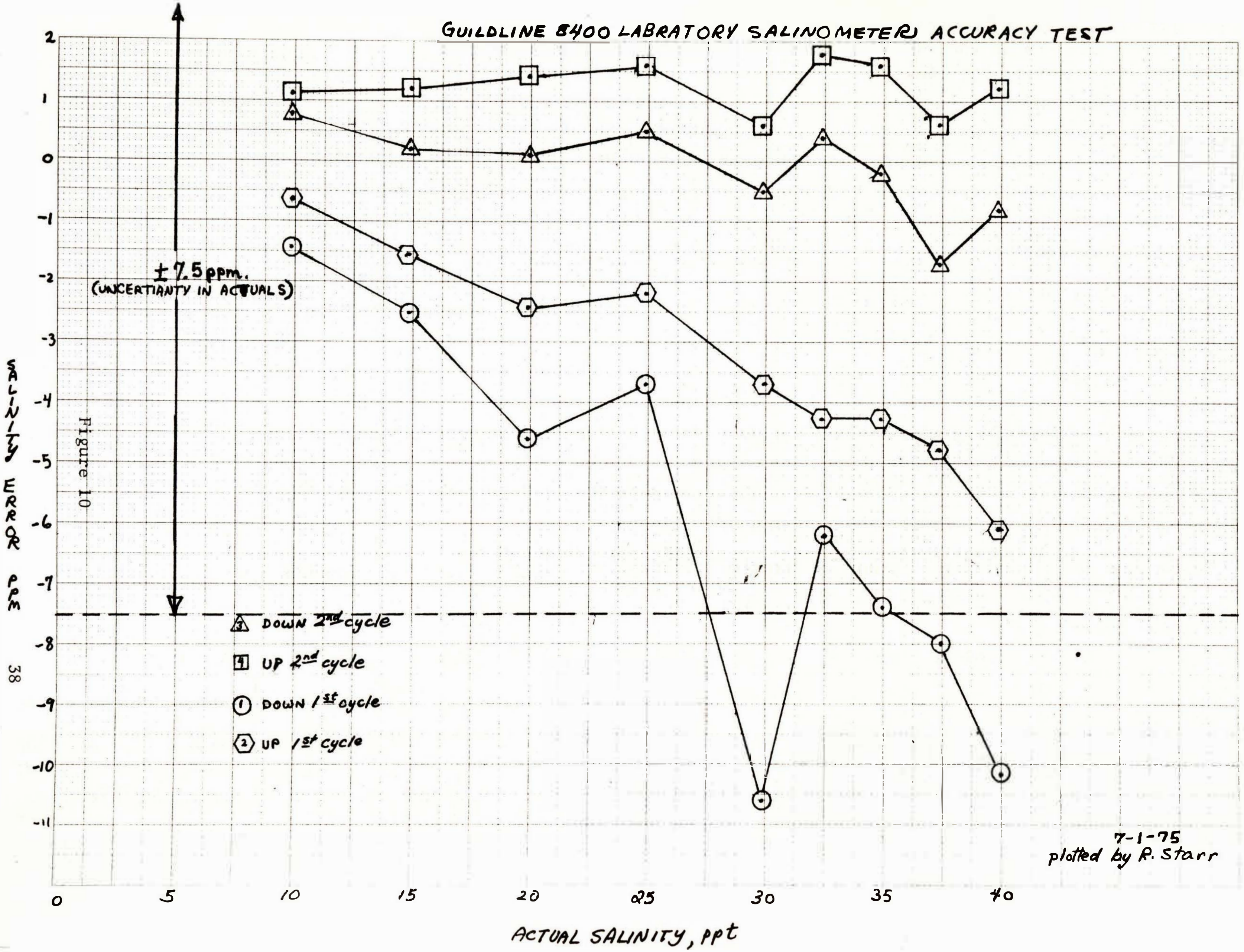

GUILDLINE 8400 LABORATORY SALINOMETER ACCURACY TEST
SALINITY ERROR PPM
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
± 7.5 ppm.
(UNCERTIANTY IN ACTUALS)
△ DOWN 2nd cycle
□ UP 2nd cycle
○ DOWN 1st cycle
⬡ UP 1st cycle
0
5
10
15
20
25
30
35
40
ACTUAL SALINITY, ppt
7-1-75
plotted by R. Starr

Figure 10

the results of this test in salinity units. The Autosal measurements always showed higher salinities on successive half-cycle runs. Since the samples for each test salinity were drawn from the same bottle, it is suspected that significant sample evaporation occurred everytime the cap was removed from the bottle for subsequent measurements, thus indicating higher salinities. The test is going to be run, but this time each discrete salinity test sample will be prepared in its own bottle prior to taking measurements. Of the data shown in Figure , the down 1st cycle (①) should be the most accurate; therefore,the data from the rerun test should cluster around this curve.

4. A 30-day stability/repeatability test was performed using sub-standard solution of about 35 ppt. Table III shows the daily measurements; variation was -0.00006 → 0.00005 in ratio (-1.2 → 1.0 ppm salinity).

C. Future Plans

Rerun salinity accuracy tests; write and publish Instrument Fact Sheet. This effort should be completed by the later part of August 1975.

GUILDLINE MODEL 8700, MARK IV DIGITIZED OCEANOGRAPHIC DATA COLLECTION SYSTEM

A. Description

The system is designed to provide in-situ digital measurements of conductivity, temperature, and pressure (depth) utilizing pulse amplitude techniques of data transmission over a possible length of 6,000 meters of single conductor cable.

The basic Mark IV System consists of an underwater probe and shipboard deck unit. The underwater unit consists of a lightweight aluminum pressure case which internally contains the associated electronics for the sensors, digitizer, multiplexer and data transmission circuits. A block diagram of this circuitry is shown in Figure 11.

The CTD sensors are located in a cage which is mounted on the pressure case.

Data obtained by the underwater unit is derived simultaneously for all three parameters which is then stored and transmitted sequentially to the surface by bi-polar pulses.

The associated shipboard unit circuits process the information to produce 16-bit binary readings and decodes these to decimal with illuminated displays for each parameter.

AUTOSAL STABILITY & REPEATABILITY

TABLE III

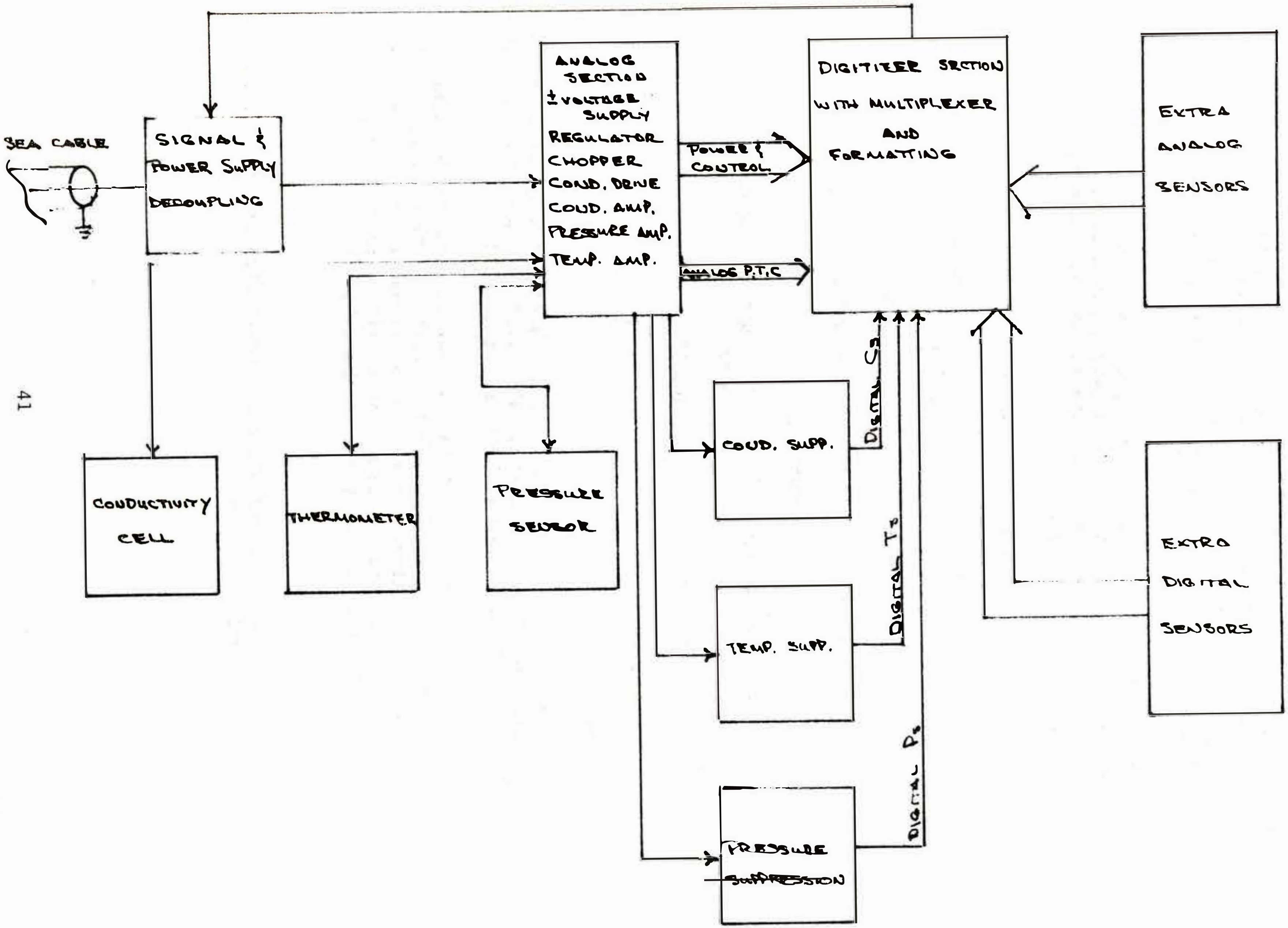
SUB-STD RATIO - 0.999724

$\overline{\text{READ}}$: 30 Readouts BATH TEMP: 23.973°C

DATE	STBY	ZERO	STANDARDIZE	$\overline{\text{READ}}$	STD DEV X10^{-5}	CHANGE	R/S TRIM
5-6-75	24+8379	0.0+0002	1.99944	1.99944	0.254	REF.	7.64
5-7-75	24+8379	0.0+0002		1.99943	2.664	-0.00001	
5-8-75	24+8378	0.0+0002		1.99942	0.568	-0.00002	
5-9-75	24+8379	0.0+0002		1.99940	0.434	-0.00004	
5-12-75	24+8378	0.0+0002		1.99944	1.192	0.00000	
5-13-75	24+8379	0.0+0002		1.99941	0.498	-0.00003	
5-14-75	24+8379	0.0+0002		1.99941	0.568	-0.00003	
5-15-75	24+8379	0.0+0002		1.99941	0.490	-0.00003	
5-16-75	24+8379	0.0+0002		1.99940	0.507	-0.00004	
5-19-75	24+8379	0.0+0001		1.99949	0.460	+0.00005	
5-20-75	24+8379	0.0+0002		1.99943	0.450	-0.00001	
5-21-75	24+8379	0.0+0002		1.99941	0.504	-0.00003	
5-22-75	24+8378	0.0+0002		1.99938	0.648	-0.00006	
5-23-75	24+8379	0.0+0002		1.99938	0.320	-0.00006	
5-27-75	24+8378	0.0+0002		1.99940	0.651	-0.00004	
5-28-75	24+8377	0.0+0001		1.99945	0.592	+0.00001	
5-29-75	24+8377	0.0+0001		1.99948	0.531	+0.00004	
5-30-75	24+8377	0.0+0002		1.99949	0.827	+0.00005	
6-2-75	24+8378	0.0+0001		1.99949	0.481	+0.00005	
6-3-75	24+8378	0.0+0001		1.99948	0.728	+0.00004	
6-4-75	24+8378	0.0+0001		1.99948	0.681	+0.00004	
6-5-75	24+8378	0.0+0001		1.99944	0.504	0.00000	
6-6-75	24+8377	0.0+0001		1.99944	0.556	0.00000	

Figure 11

DIGITAL CTD PROBE BLOCK DIAGRAM



The underwater probe is designed for ease of field maintenance without disturbance of calibrated accuracy. Modular construction is used throughout each circuit function and is finished in the form of interchangeable plug-in circuit boards and sensors which can be independently calibrated. The conductivity cell is an electrode type which is known to have much reduced proximity or "area" effect associated with induction type cells.

Response time of all sensors are specified to be better than 50 milliseconds at a drop rate of 1.5 meters per second. Specified parameter measurement ranges and accuracies for the unit to be tested at the Center are given below:

Measurement Ranges

Conductivity	28 to 40 ppt in equivalent salinity
Temperature	-2° → 40°C
Pressure	5,000 meters

Accuracies

Conductivity	±0.01 ppt in equivalent salinity
Temperature	±0.01°C
Pressure	±0.15% FS

B. Progress

Procurement action was initiated by the Naval Oceanographic Office for two Model 8700, Mark IV Systems. The first system will be delivered to NOO in July and the second to NOIC in August 1975.

A laboratory performance test and evaluation plan was developed. NOO will test the system in the field (NOIC's fish will be used as a backup unit) and perform laboratory tests from the standpoint of reliability, supportability, and maintainability. NOIC will perform measurement, performance, and environmental tests in the laboratory.

C. Future Plans

Perform six months of performance and environmental tests on the system beginning in September 1975.

NEIL BROWN CTD SYSTEM (MK III)

A. Description

The system is designed to provide high resolution, high speed and high accuracy conductivity, temperature and pressure data suitable for classical deep ocean hydrographical observations as well as specialized microstructure studies.

The basic system consists of two components - the underwater unit and the shipboard unit. The underwater unit consists of three (3) sensors with their interface circuits, oscillator, digitizer, multiplexer, data formatter and data transmission circuits. C, T & P sensor outputs are digitized to 16 bit "words" 30 times per second and transmitted serially to the shipboard unit in Teletype format using frequency shift-keyed (FSK) modulation. The particular FSK modulation parameters used permits reliable recording of the signal from the underwater unit using an unmodified inexpensive audio tape recorder. Data subsequently replayed from the recorder is indistinguishable from the original as far as the shipboard unit is concerned. This feature provides very inexpensive and effective back-up capability in the event that a shipboard computer is not available for any reason.

The shipboard unit consists of a demodulator, digital display and D to A converters. The signal from the underwater unit is demodulated and the resulting serial digital output can be inputted directly to a computer (e.g. Hewlett-Packard 2116 or 2100) via a standard Teletype I/O card. Additional decoding logic provides parallel outputs for computers requiring parallel inputs (e.g. IBM 1800). This logic also provides BCD outputs to the display modules and the D to A channels.

1. System Specifications

	Ranges
Pressure	Full scale ranges of 650, 1600, 3200 and 6500 meters
Temperature	0 → ±32°C
Conductivity	20 → 65 mmhos

2. Accuracy

	Short term	3 months
Temperature	±0.003°C	±0.005°C
Conductivity	±0.003 mmhos	±0.005 mmhos
Pressure	±0.075% of F.S.	±0.1% F.S.

Accuracy includes linearity, hysteresis, temperature effects in all cases.

the "current electrodes." The resistance defined in this way is completely independent of the polarization impedance which occurs at the electrode - electrolyte interface.

One of the important advantages of this cell is the fact that it can be drastically scaled down in size for microstructure measurements without significantly reducing its accuracy. The inductively-coupled conductivity sensor used very widely in the past cannot be scaled down without introducing unacceptable errors. Furthermore, the signal-to-noise ratio of the 4-electrode cell is several orders of magnitude better than the inductivity-coupled sensor.

C. Pressure - Pressure is measured using a strain-gage pressure transducer. At the present time, the best accuracy available is ±0.05%. However, as better transducers are available they will be incorporated into the system.

B. Progress

The Naval Oceanographic Office has initiated procurement on one system with two underwater units (fish) and are scheduled for delivery in late July 1975. The test objectives are the same for both parties (NOO and NOIC) as on the Guildiine Model 8700 CTD System previously described.

C. Future Plans

Perform six months of performance and environmental tests on the system which are tentatively scheduled to begin around January 1976.

3. Resolution

Temperature	±0.0005°C
Conductivity	±0.001 mmhos
Pressure	±0.0015% of F.S.

4. Sampling Rate

Each parameter is sampled 30 times per second. However, a special version of the instrument would be available at a later date which would sample at up to 100 times per second. The standard unit of course can be set for lower sampling rates if desired.

5. Sensor Description

A. Temperature - Temperature is measured using a precision platinum resistance thermometer (response time 250 mS) and a miniature high speed thermistor probe (30 mS). The thermistor circuit output voltage is automatically and precisely nulled in an electronically balanced bridge using an electronic servo having a response time equal to that of the platinum thermometer. Slowly changing thermistor resistance including those due to thermistor calibration drift results in zero output from the bridge. However, rapid changes in temperature result in a momentary unbalanced output from the thermistor bridge which is equal and opposite to the lag in the platinum thermometer. Hence the sum of these sensor outputs is the same as would be expected if the platinum thermometer were operating alone and had a time constant of 30 mS instead of its 250 mS value. Thus temperature is sensed with the excellent stability and linearity of the platinum thermometer and speed of miniature thermistors without paying the penalty of thermistor calibration drift.

Since the thermistor and conductivity cell are within 5 mm of each other, the very high speed temperature sensing virtually eliminates the serious problem of "salinity spikes" that are typical of other systems.

B. Conductivity - Conductivity is measured using a 4-electrode (platinum) conductivity cell having a length of 8 mm and an inside diameter of 2 mm. The 4-electrode cell has excellent stability and is not sensitive to changes in electrode polarization impedance as is the case for the simple 2-electrode cell.

The 4-electrode cell is analogous to a 4-terminal resistor in that the cell resistance is defined by measuring the ratio of the open circuit voltage at the "voltage electrodes" to the current applied at

CURRENT MEASURING INSTRUMENTATION

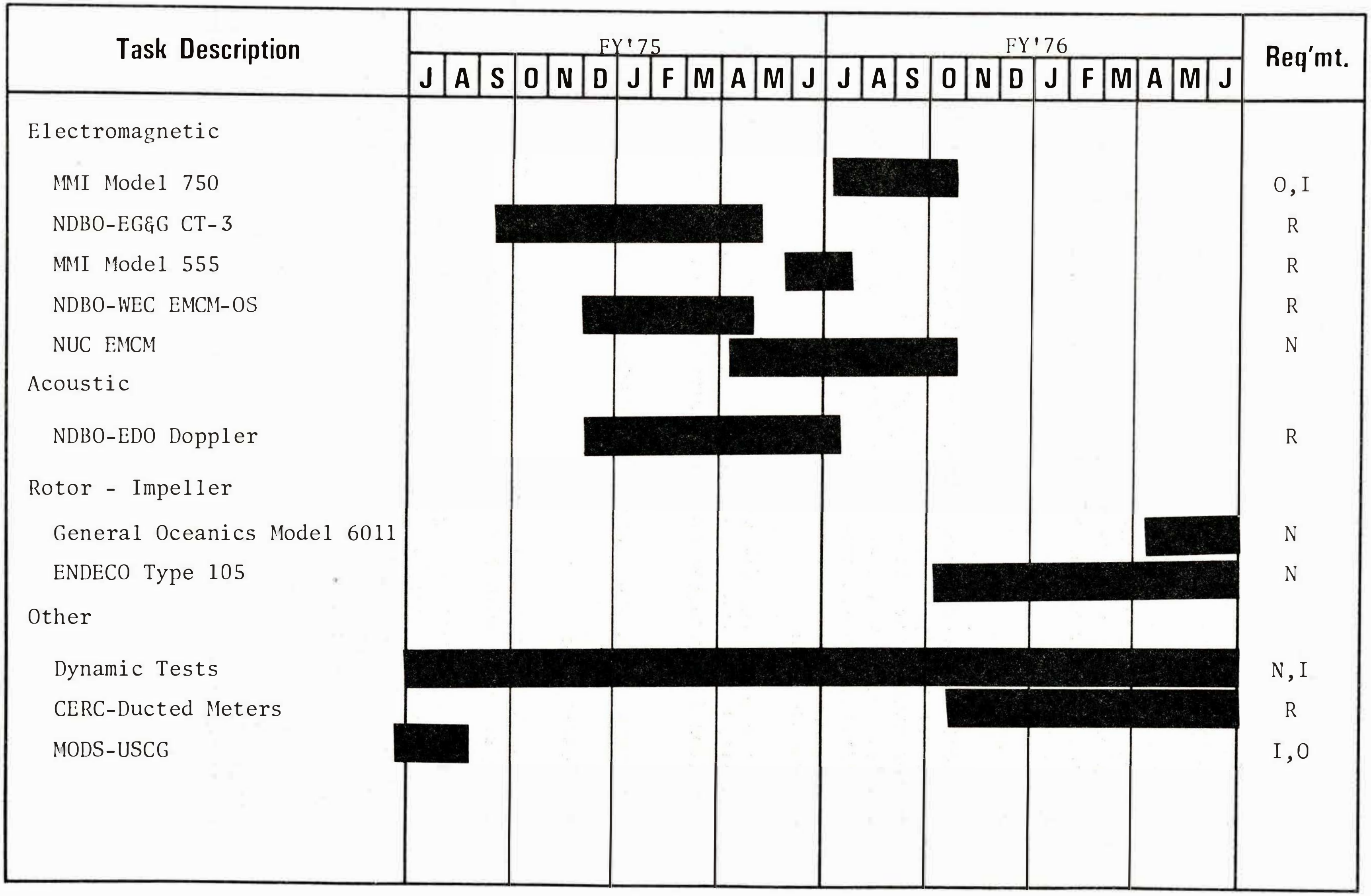
TESTING PROGRAM

Date: July 1, 1975

Project: Current Meters

Project Leader: G. Appell

N — **Navy** **R** — **Reimbursable**
I — **In-House** **O** — **Other**



Task Description	Req'mt.
Electromagnetic	
MMI Model 750	O,I
NDBO-EG&G CT-3	R
MMI Model 555	R
NDBO-WEC EMCM-OS	R
NUC EMCM	N
Acoustic	
NDBO-EDO Doppler	R
Rotor - Impeller	
General Oceanics Model 6011	N
ENDECO Type 105	N
Other	
Dynamic Tests	N,I
CERC-Ducted Meters	R
MODS-USCG	I,O

MARSH-MCBIRNEY INC. (MMI) MODEL 750 ELECTROMAGNETIC CURRENT METER

A. Description

The MMI Model 750 meter is a solid state, no moving parts instrument designed to measure two orthogonal components of water current velocity simultaneously in a plane perpendicular to the transducer.

The original model 750 has been redesigned with extended electrodes rather than the original concept of raised ridges. The reason for the redesign was to measure outside of the boundary layer and therefore, hopefully minimize the effect of boundary disturbances on cylindrical type sensors.

B. Progress

NOIC received a new sensor from MMI with the extended electrodes. At approximately the same time, MMI developed a model 555 spherical sensor which they claim has superior performance to the cylindrical models. Brief tests were performed on a prototype model 555 for NDBO and performance was promising.

C. Future Plans

In view of the new model 555 development, the model 750 has been cancelled from the evaluation program. The sensor, however, will be utilized in a program to study turbulence effects on sensors.

EG&G MODEL CT/3 ELECTROMAGNETIC CURRENT METER

A. Description

The NOAA Data Buoy Office (NDBO) provided two CT/3 current measuring systems to NOIC for a limited performance evaluation.

The EG&G-CT/3 is a self-orienting single axis electromagnetic current meter. The meter is enclosed in a prolate spheroid (torpedo-shaped), finned housing which secures to a bottom anchored buoy mooring and which aligns with current direction. An internal flux-gate compass senses magnetic North.

Current velocity magnitude is measured by a pair of "uni-probe" transducers which combine both electrode and excitation coil in a single unit. The current meter provides a record of elapsed time, water temperature and current speed and direction on digital magnetic tape cassette.

B. Progress

Tests have been completed, and a report was sent to NDBO. An IFS is in preparation.

C. Future Plans

None.

MARSH MCBIRNEY INC. (MMI) MODEL 555 ELECTROMAGNETIC CURRENT METER

A. Description

The MMI model 555 is a solid state, no moving parts spherical electromagnetic current transducer. A complete self-contained instrument package is available. The spherical transducer is 4 inches in diameter with four extended electrodes mounted on the periphery of the sphere. Two orthogonal components of the water current velocity vector are measured in a plane perpendicular to the transducer axis.

A prototype transducer was tested by NOIC for NDBO in order to indicate the sensors performance for use on surface-moored platforms.

B. Progress

Tests have been completed and a report was sent to NDBO.

C. Future Plans

None.

WESTINGHOUSE/NDBO OCEAN SENSORS

A. Description

The systems were developed for the NOAA Data Buoy Office (NDBO) by Westinghouse Electric Corporation (WEC). NDBO has requested NOIC to perform a limited evaluation on two systems on a reimbursable basis.

One Ocean Sensor contains an Edo Western Acoustic Doppler current meter. The acoustic doppler works on the principle that a doppler shift occurs to the frequency of a transmitted acoustic signal by water particles in the beam's axis. The doppler-shifted frequency is detected by a receiver and is proportional to velocity.

A second Ocean Sensor contains an MMI electromagnetic current meter and operates as a self-contained system. The transducer is an MMI Model 750 EMCM with two measurement axis. A flux-gate compass is used for orientation to North and the system is vaned into the flow. All information is digitized and recorded internally on cassette magnetic tape.

B. Progress

Tests have been completed and a report was sent to NDBO.

C. Future Plans

None.

NAVAL UNDERWATER CENTER (NUC) ELECTROMAGNETIC CURRENT METER

A. Description

Jack Olson of NUC developed this instrument several years ago in response to a specific requirement for current measurement from NUC's test tower. It represents the only "open" electromagnetic configuration available. Its distinction from other EMCMs is in the transducer design; a Helmholtz coil inside of which is placed 2 pairs of electrodes, hence the "open" designation. It is hoped that the hydrodynamic problems of the other type transducers will be minimized in this design.

B. Progress

Preliminary tests have been completed on both the Scripps low velocity sensors and the AC powered units. These instruments are not commercial grade and are delicate and must be pampered to operate properly. Considerable time has been consumed in familiarization and overcoming apparent malfunctions.

The AC powered units utilize a sine-wave magnet drive resulting in zero drift problems that have diminished the quality of the test data. Figures 12 through 14 depict preliminary calibration and directivity data obtained during tests at NSRDC.

C. Future Plans

Recently obtained test data will be analyzed and the need for additional tests determined. If the quality of these test results are favorable, a report will be prepared.

GENERAL OCEANICS MODEL 6011 INCLINOMETER CURRENT METER

A. Description

This type of current meter has no moving parts and measures current by sensing the magnitude and direction of tilt of its own housing. The instrument mounts to a special tether and swivel attached to the mooring that allows the housing to lean with the current that is to be measured.

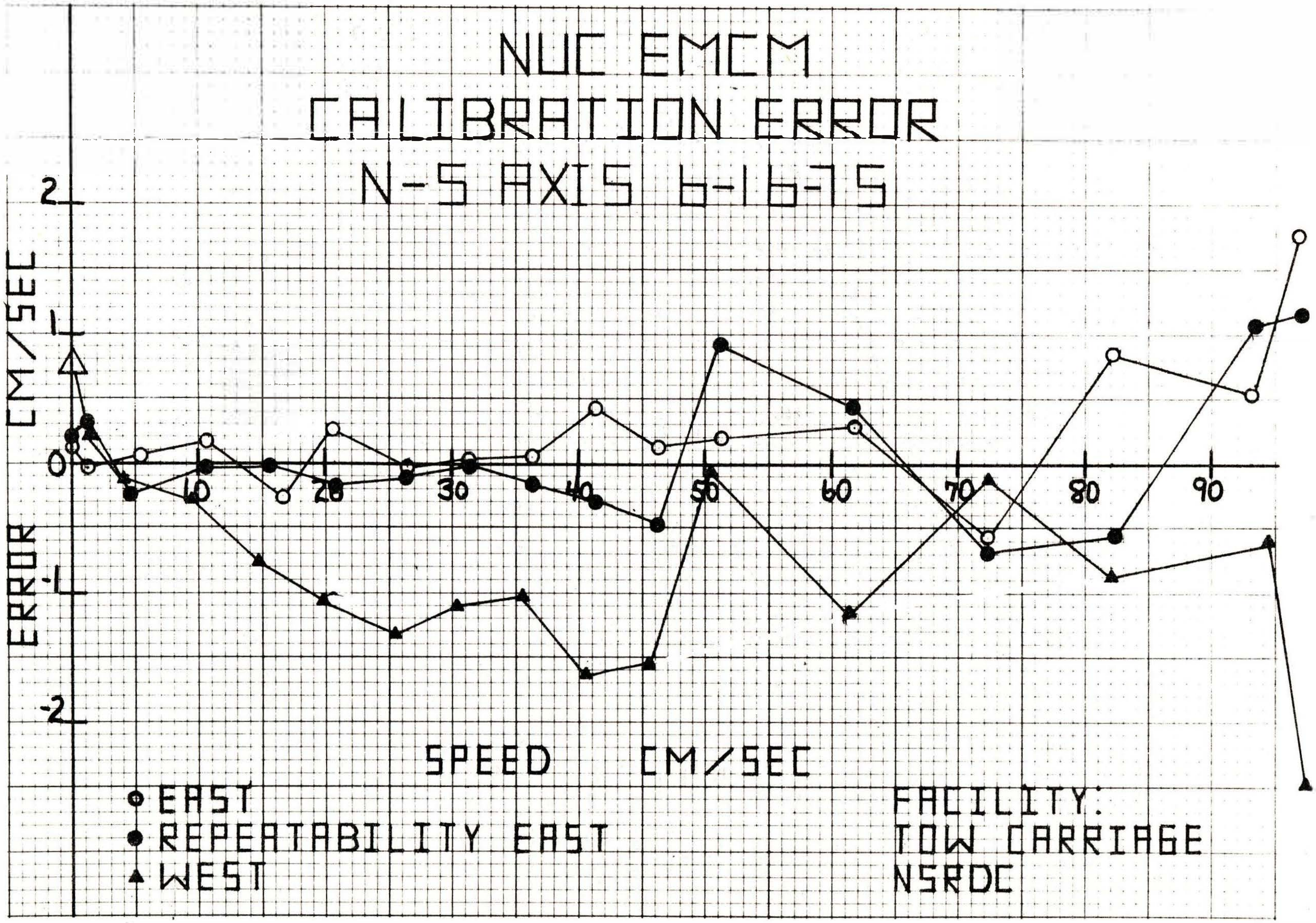

NUC EMCM
CALIBRATION ERROR
N-S AXIS 6-16-75
ERROR CM/SEC
2
1
0
-1
-2
10
20
30
40
50
60
70
80
90
SPEED CM/SEC
○ EAST
● REPEATABILITY EAST
▲ WEST
FACILITY:
TOW CARRIAGE
NSRDC

Figure 12

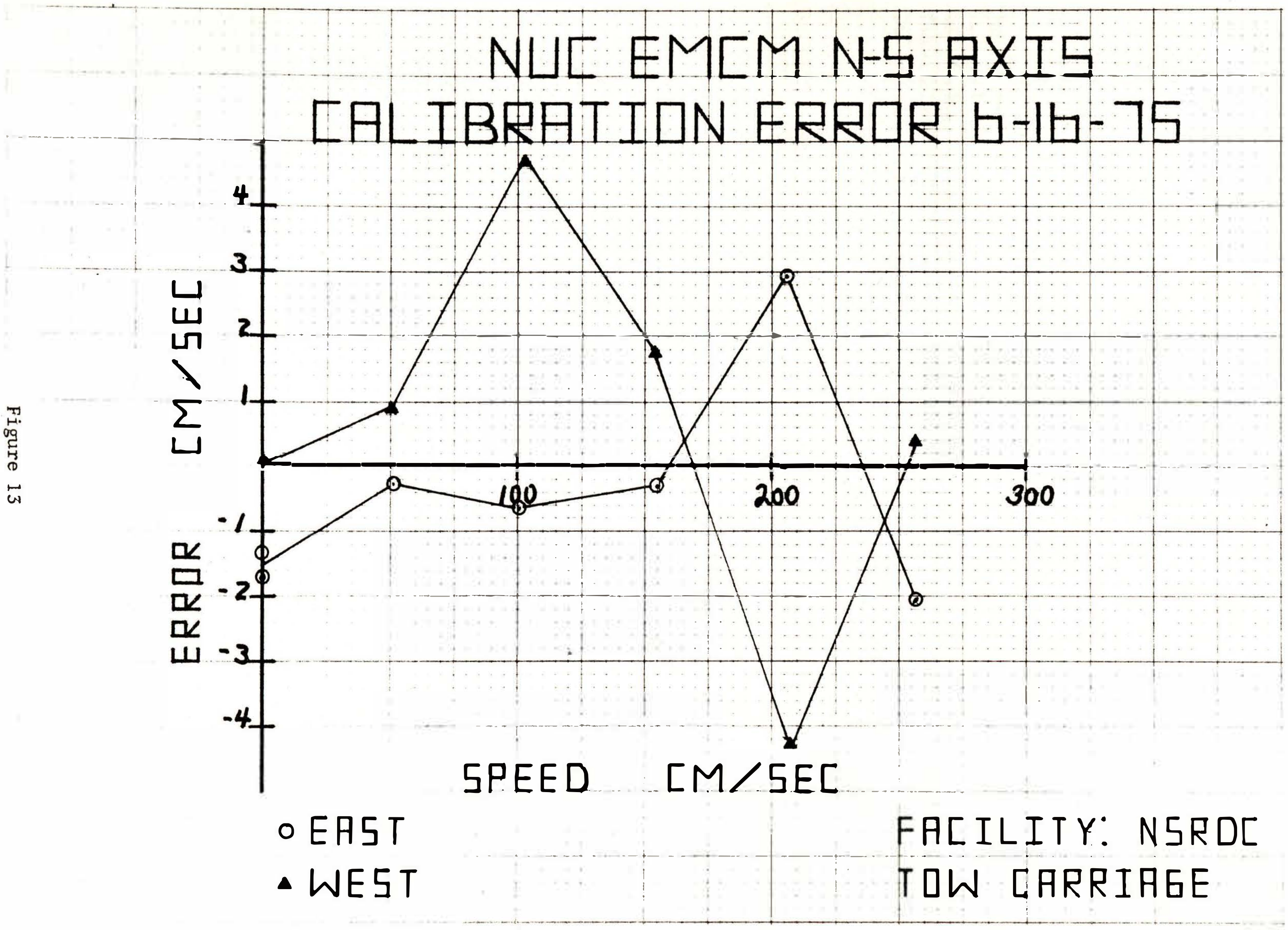

NUC EMCM N-S AXIS
CALIBRATION ERROR 6-16-75
4
3
2
1
-1
-2
-3
-4
ERROR CM/SEC
100
200
300
SPEED CM/SEC
○ EAST
▲ WEST
FACILITY: NSRDC
TOW CARRIAGE

Figure 13

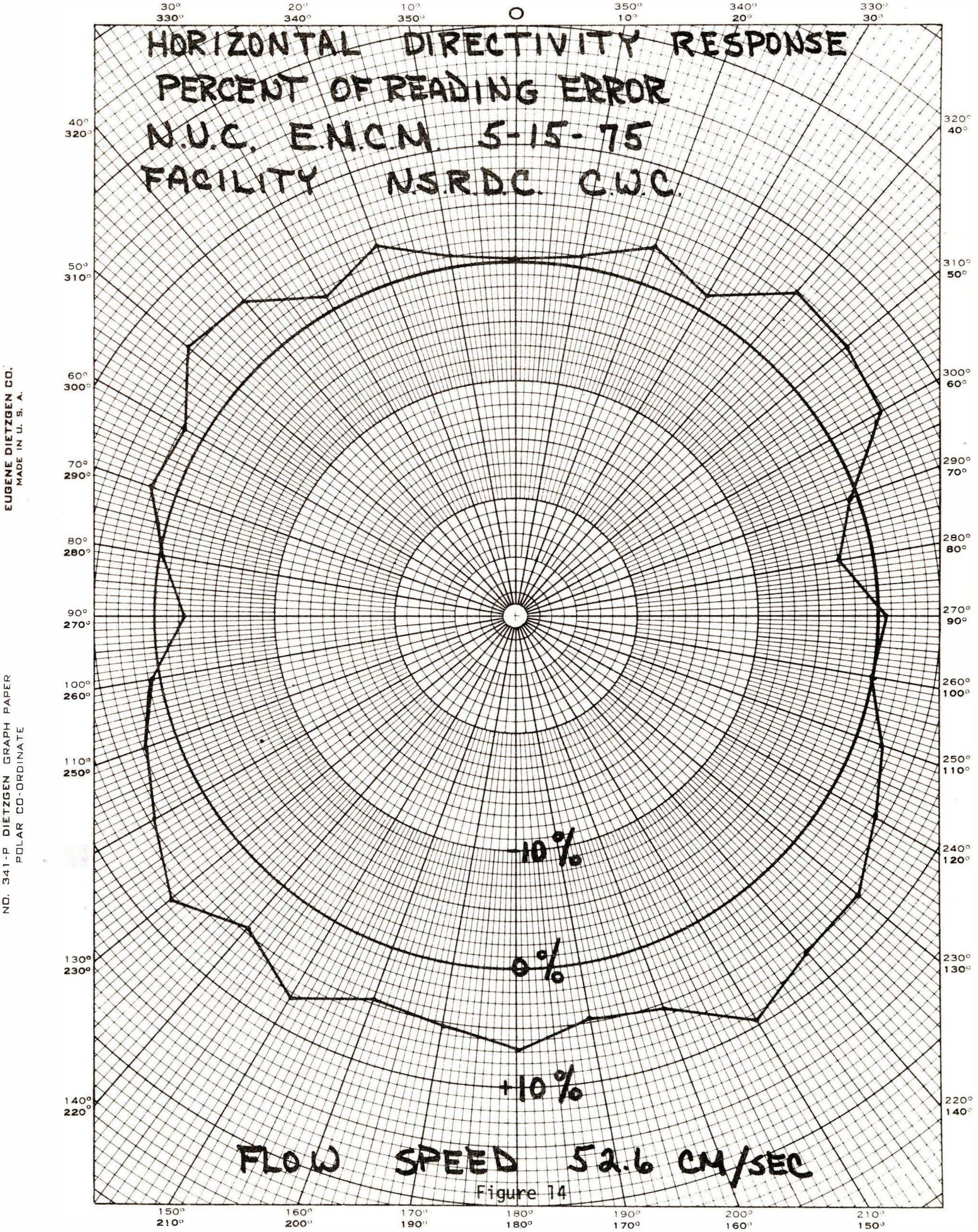

HORIZONTAL DIRECTIVITY RESPONSE
PERCENT OF READING ERROR
N.U.C. E.N.C.M. 5-15-75
FACILITY N.S.R.D.C. C.W.C.
-10%
0%
+10%
FLOW SPEED 52.6 CM/SEC
0
30° 330°
20° 340°
10° 350°
350° 10°
340° 20°
330° 30°
40° 320°
50° 310°
60° 300°
70° 290°
80° 280°
90° 270°
100° 260°
110° 250°
130° 230°
140° 220°
320° 40°
310° 50°
300° 60°
290° 70°
280° 80°
270° 90°
260° 100°
250° 110°
240° 120°
230° 130°
220° 140°
150° 210°
160° 200°
170° 190°
180° 180°
190° 170°
200° 160°
210° 150°
EUGENE DIETZGEN CO.
MADE IN U. S. A.
NO. 341-P DIETZGEN GRAPH PAPER
POLAR CO-ORDINATE

Figure 14

Internal tape recording (replaces film recording of model 2010) of an accelerometer output yield the angle on inclination and two Hall-effect sensors yield magnetic north orientation.

B. Progress

None.

C. Future Plans

Tests are planned to begin in May of 1976.

ENDECO TYPE 105 SELF-CONTAINED TETHERED CURRENT METER (TCM)

A. Description

The Endeco type 105 Tethered Current Meter attaches to a mooring line by a five-foot long tether line. The resilient tether and the neutral bouyancy of the instrument is designed to allow mooring cable motions to occur without their effects to be transmitted to the instrument.

The instrument senses current speed with an impellor and direction with a magnetic compass and alignment of the sensor into the flow. Data is recorded on 16 mm tri-x film magazine.

B. Progress

None.

C. Future Plans

Tests are scheduled to begin in January of 1976.

CURRENT METER DYNAMIC RESPONSE STUDY

A. Description

The dynamic response characteristics of a current speed and direction sensor may severely limit its in-situ measurement capabilities. For example, it has been found that platform/mooring motions introduce significant errors in the average current vector measured by current meters supported by moorings. Also, the imperfect dynamic response characteristics inherent in current meters present additional measurement deficiencies for near surface current determinations (wave water particle region).

Historically, almost all current meter performance evaluations conducted in the laboratory have been under steady flow conditions. Unfortunately, these conditions are not very representative of the typical in-situ environment. Therefore, in July 1972, NOIC initiated a program to develop realistics dynamic test standards for current meters.

B. Progress

A dynamic test fixture capable of simultaneously imparting two degrees of freedom (simulating longitudinal, lateral, vertical/ horizontal elliptical, vertical orbital motion) is being designed by NSRDC. This fixture, to be used on the NSRDC tow carriage, will be capable of testing full size current meters at up to 4 foot peak-to-peak amplitudes (adjustable) and from 12 to 3 second periods. It is envisioned that once this fixture has been fabricated and validated it will be utilized for current meter dynamic investigations.

C. Future Plans

The fabrication and validation of the dynamic test fixture will commence when the design is completed. Permission from NSRDC to allow this device on their tow carriage has been granted and $40K has been transferred. Completion of fabrication is estimated to be January 1, 1976.

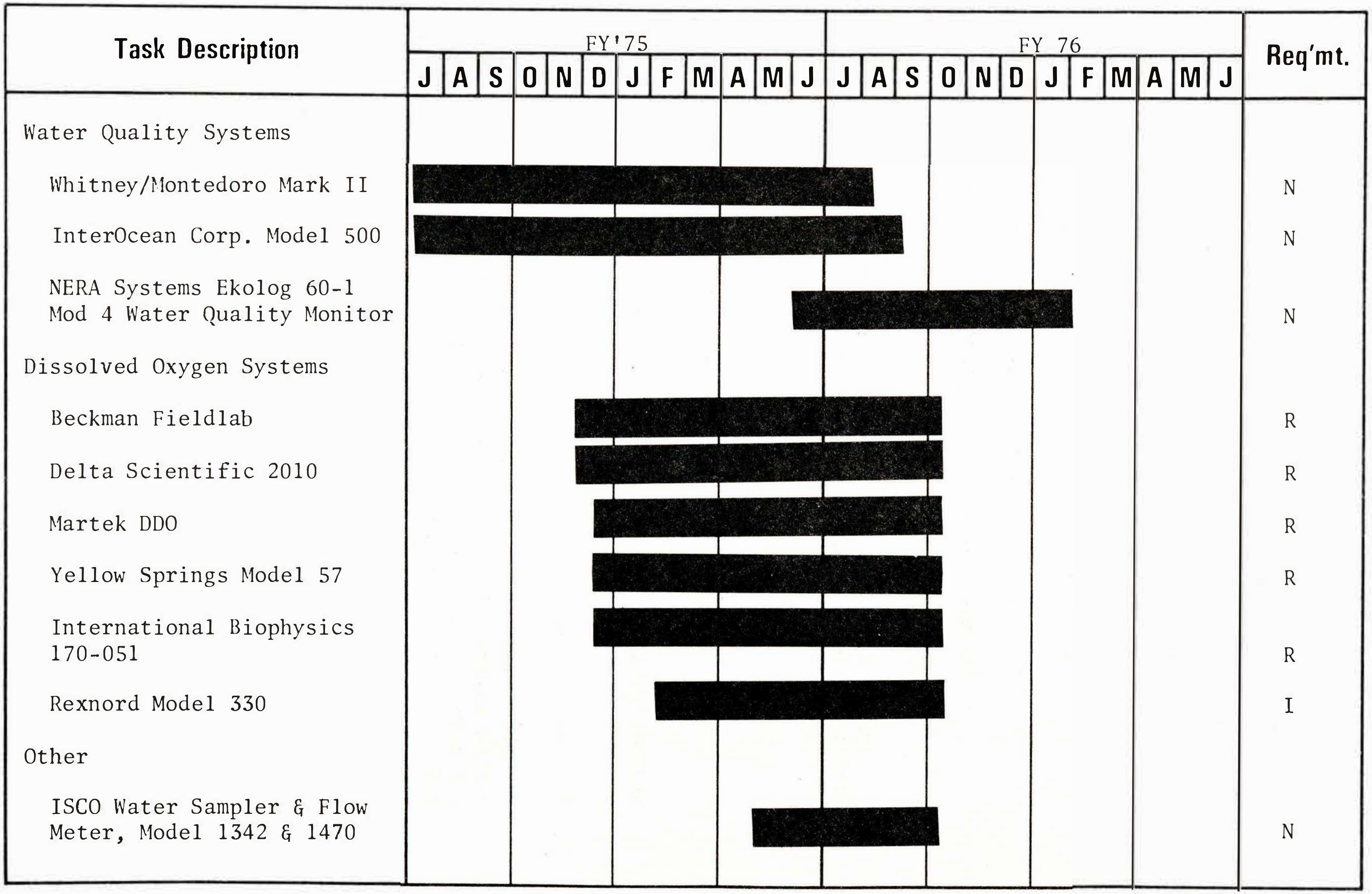
WATER QUALITY INSTRUMENTATION

TESTING PROGRAM

Date: July 1, 1975

Project: Water Quality
Project Leader: B. Pijanowski

N — Navy
I — In-House
R — Reimbursable
O — Other



Task Description	Req'mt.
Water Quality Systems	
Whitney/Montedoro Mark II	N
InterOcean Corp. Model 500	N
NERA Systems Ekolog 60-1 Mod 4 Water Quality Monitor	N
Dissolved Oxygen Systems	
Beckman Fieldlab	R
Delta Scientific 2010	R
Martek DDO	R
Yellow Springs Model 57	R
International Biophysics 170-051	R
Rexnord Model 330	I
Other	
ISCO Water Sampler & Flow Meter, Model 1342 & 1470	N

WATER QUALITY SYSTEMS - CONTINUING TESTS

A. Description

Two water quality systems previously tested and reported in IFS form were tested for pH calibration stability. In addition, two laboratory pH meters were included in the test. The units tested were:

Leeds and Northrup Water Quality System, IFS-75005

HydroLab Corp. Surveyor Model 6D,-IFS-75004

Beckman Instruments Digital pH Meter

Beckman Instruments EXPANDOMATIC pH Meter

B. Progress

pH calibration stability was tested for 30 days to simulate conditions experienced during long term monitoring. Results are presented in figure 15.

C. Future Plans

No further testing is planned on these units.

WHITNEY/MONTEDORO CORPORATION MARK II PORTABLE WATER QUALITY MONITORING SYSTEM

A. Description

This system is designed to measure temperature, conductivity, dissolved oxygen, pH and Chloride ion concentration in situ to a depth of 100 meters. Temperature is measured by thermistor, conductivity by an inductive cell, dissolved oxygen by a pressure and temperature compensated polarographic membrane sensor, pH by a pressure compensated glass electrode and Chloride ion by a specific ion electrode. Output for all parameters is digital. Instrument specifications are listed in Table IV.

This is an improved version of the system originally tested in January 1972. According to the manufacturer, repairs and extensive modifications have been made.

B. Progress

All tests with the exception of an environmental evaluation have been completed, however, dissolved oxygen data has not yet been reduced. Conductivity calibration error is shown in figure 16, but this data may not

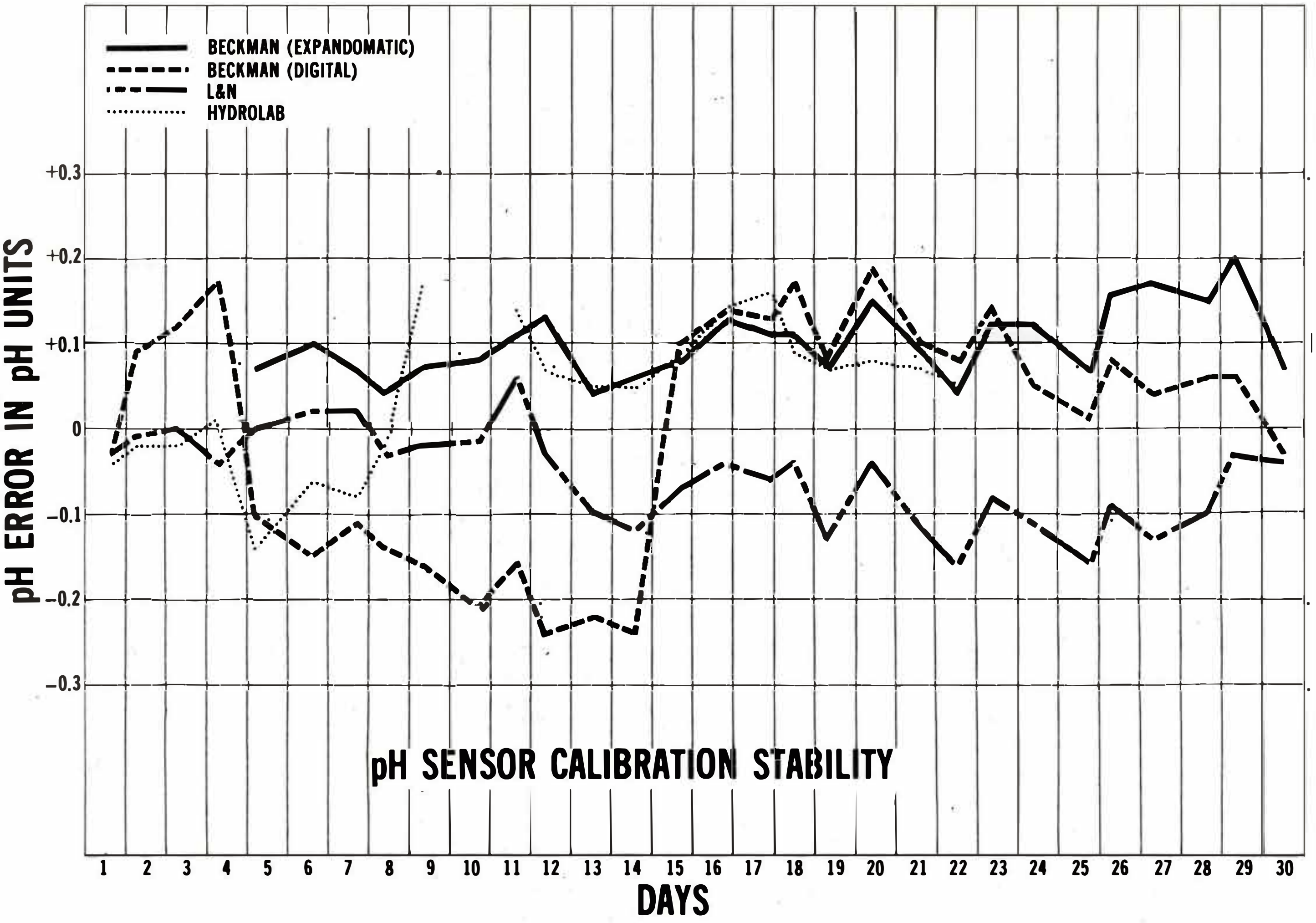

BECKMAN (EXPANDOMATIC)
BECKMAN (DIGITAL)
L&N
HYDROLAB
+0.3
+0.2
+0.1
0
−0.1
−0.2
−0.3
pH ERROR IN pH UNITS
pH SENSOR CALIBRATION STABILITY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
DAYS

Figure 15

SPECIFICATIONS FOR WATER QUALITY SYSTEMS

TABLE IV	INTEROCEAN 513D	WHITNEY-MONTEDORO
Conductivity		
Range	0-65 mmho/cm	0.01 - 100 mmho/cm
Accuracy	±0.05 mmho/cm	±0.05 mmho/cm
Sensor	Inductive cell t.c. - 10ms	Inductive cell (20°C,35°/oo Na Cl)*
Temperature		
Range	-5 to 45°C	0 to 40°C
Accuracy	±0.05°C	±0.1°C
Sensor	Thermistor Network t.c. - 1.4s	Rt - 5s
Depth		
Range	0-100M	0-100M
Accuracy	±1.M 25% overrange	±0.4M 165 psi max
Sensor	tc-50ms Strain gauge bridge	Solid state *
Dissolved Oxygen		
Range	0-40 ppm	0-20 ppm
Accuracy	±0.2 ppm	±0.2 ppm
Sensor	Ag/Pt polarographic (Beckman) t.c. - 10s *	Au/Ag polarographic Rt - 10s *
pH		
Range	2-14 pH	2-12 pH
Accuracy	±0.1 pH	±0.05 pH
Sensor	Combination Ag/AgCl (Beckman) t.c. - 200MS *	Combination Ag/AgCl pressure comp. Rt - 10S.Max *
Power	External AC or DC +15V -15V	Internal Globe Gel Cells (2) 12V-rechargeable External 12V DC
Environmental Conditions	-5 to 50°C	

*Temperature Compensated

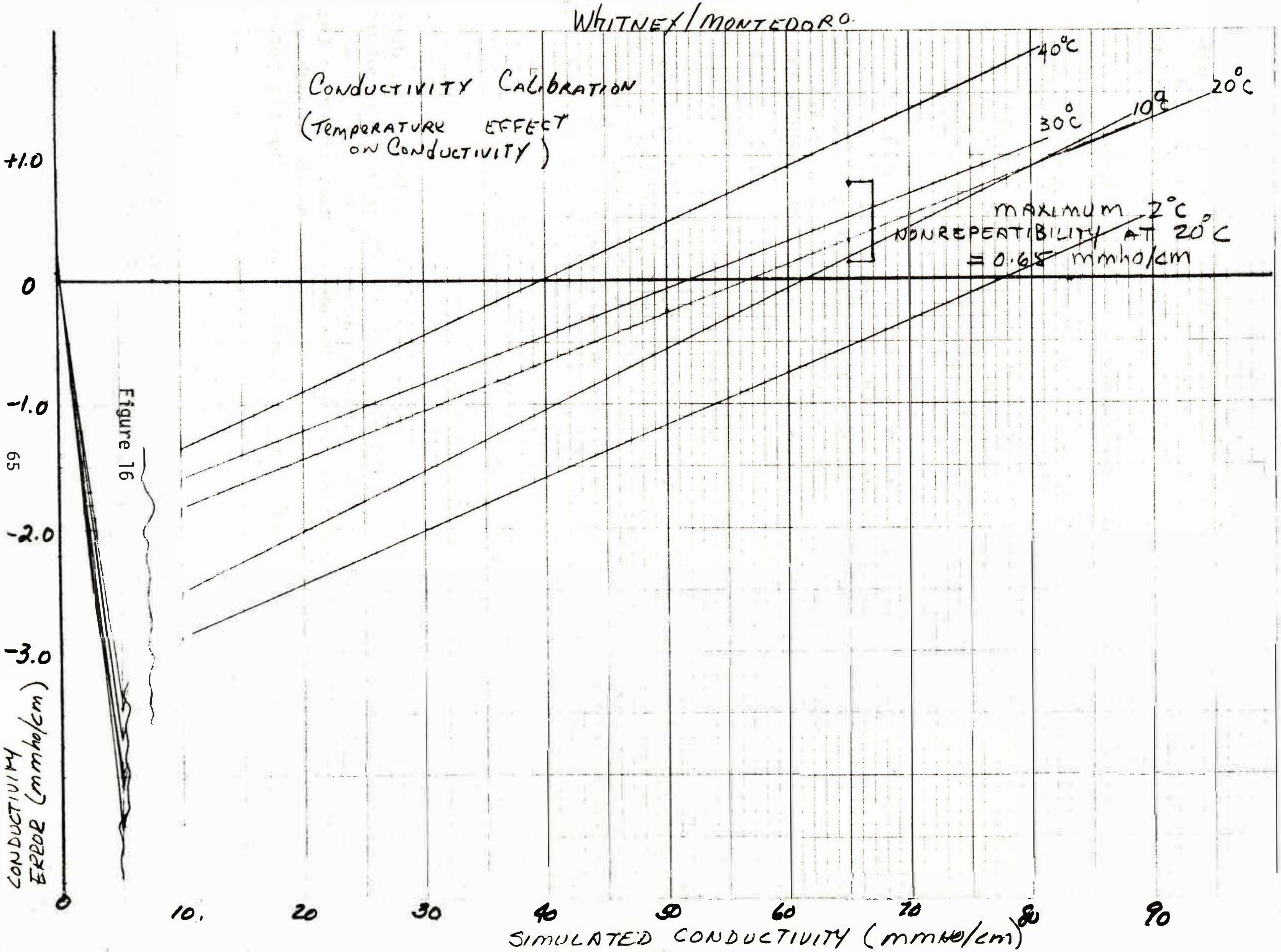

WHITNEY/MONTEDORO
CONDUCTIVITY CALIBRATION
(TEMPERATURE EFFECT ON CONDUCTIVITY)
40°C
30°C
10°C
20°C
MAXIMUM 2°C NONREPEATIBILITY AT 20°C
= 0.65 mmho/cm
+1.0
0
-1.0
-2.0
-3.0
CONDUCTIVITY ERROR (mmho/cm)
0
10.
20
30
40
50
60
70
80
90
SIMULATED CONDUCTIVITY (mmho/cm)

Figure 16

be representative of a properly functioning sensor. Although it appeared to be operating properly during the tests, a later problem with the dissolved oxygen sensor proved to be the result of a leaky conductivity probe. The new conductivity probe has not yet been supplied by the manufacturer for retesting. An A to D converter circuit board was also replaced during the past six months.

Field testing on the unit pointed out several problems:

(1) Longest operating life can be attained with an external 12V power supply. In the field, a heavy duty 12V automatic battery was used, however, when the system was used for continuous monitoring, less than 18 hours of useful data could be obtained before the battery was drained.

(2) Air freight handling of the system was unusually rough, and vibration and shock caused some internal damage on the terminal unit in spite of the fact that the unit was well packed. A complex stepping switch was broken and several circuit boards were loosened with components broken as a result.

C. Future Plans

No further evaluation of this system is planned; test results obtained to date will be published. The system has been plagued by constant failures since its original evaluation was started in the spring of 1972. Although repairs have been made under warranty, the result is that time consuming retesting is required after each repair and the unit is unlike anything now marketed by the company.

INTEROCEAN MODEL 513D CTD-DO - pH SYSTEM

A. Description

This system is designed to measure temperature, conductivity, depth, dissolved oxygen and pH in situ to depths of 100 meters. Temperature is measured by thermistor, conductivity by an inductive cell, dissolved oxygen by a temperature compensated polarographic sensor which is the Beckman Instrument Co. Fieldlab unit and pH is measured by a combination electrode with an Ag/AgCl reference. Output is digital for all parameters. Specifications are listed in Table V.

B. Progress

Conductivity tests have been repeated after the underwater unit was modified by the manufacturer to eliminate adverse temperature effects.

SPECIFICATIONS FOR DISSOLVED OXYGEN METERS

TABLE V	BECKMAN FIELDLAB	DELTA SCIENTIFIC MODEL 2010-00	INTERNATIONAL BIOPHYSICS CORP. DOA 170-051	MARTEK DDO	YELLOW SPRINGS MODEL 57	REXNORD MODEL 330 (WESTON & STACK)
Dissolved Oxygen Range	0-25 ppm	0-20 ppm	0-20 ppm 0-100% O_2	0-20 ppm 0-.4 atm (O_2) 0-200% sat.	0-20 ppm	0-15 ppm
Accuracy	±0.2 ppm	Not Specified	±2% reading	±1% F.S.	±0.1 ppm	±1% F.S.
Sensor	Ag/Pb polarographic	Ag/Au Polarographic	Ag/Au Polarographic	Ag/Au Polarographic	Ag/Au Polarographic	Pt/Pb polarographic
Temperature	0-100°C ±0.1°C	no readout (thermistor)	(no readout)	-5 to 50°C	-5 to 45°C ±0.7°C	0-50°C ±0.5°C
Power Requirements	AC or rechargeable NiCd batteries	Batteries	Batteries 4 D Cells	115 AC or DC - rechargeable	Batteries 2 C Cells 5 C NiCd for stirrer	4 D Cells 4AA Cells for Stirrer
Depth Limit	600 ft.	300 ft.	Not Specified	200 meters	250 ft.	300 ft.
Temp/Press.	Manual Temperature Compensation	Automatic Temperature & pressure Compensation	Automatic Temperature Compensation	Automatic Temperature Compensation	Automatic Temperature Compensation Manual Salinity Compensation	Automatic Temperature Compensation
Stirrer	Not required	Optional	None	Provided	Optional	Optional
Price	$700	$925	$450	$800	$850	$665

Results are presented in figure 17. Dissolved oxygen testing has been completed, however, data has not yet been reduced.

During the past six months, repairs were made on the cable. It is used to support the underwater unit as well as for data and power transmission, and normal strain during testing resulted in the parting of some of the wires. The pH circuit board in the terminal unit was also repaired because of the failure of an operational amplifier.

C. Future Plans

Environmental and pressure tests will be completed, long term stability tests will be run and an IFS will be published.

NERA SYSTEMS EKOLOG 60-1 MOD 4 WATER QUALITY MONITOR

A. Description:

This system is composed of a Hydrolab Surveyor Model 6D Water Quality unit interfaced with a portable data acquisition system manufactured by NERA Systems, Inc. The data collection rate is programmable and data is recorded on a cassette tape recorder. Data on the tapes can be reduced in conjunction with software available on the G. E. time sharing computer through remote terminals. The entire unit is operated by a 12V automotive battery and with the exception of the underwater unit is housed in a watertight carrying case.

B. Progress

The unit to be tested is composed of a Hydrolab Surveyor belonging to NOIC and a data acquisition unit on loan from NERA. The NOIC Hydrolab unit has been updated and modified to accommodate the NERA system. NERA is in the process of interfacing the system together.

C. Future Plans

Complete test and evaluation of the data collection system is planned.

DISSOLVED OXYGEN INSTRUMENTS

A. Description

All instruments measure dissolved oxygen in water. The instruments under evaluation are:

Beckman Fieldlab

Delta Scientific Model 2010-00

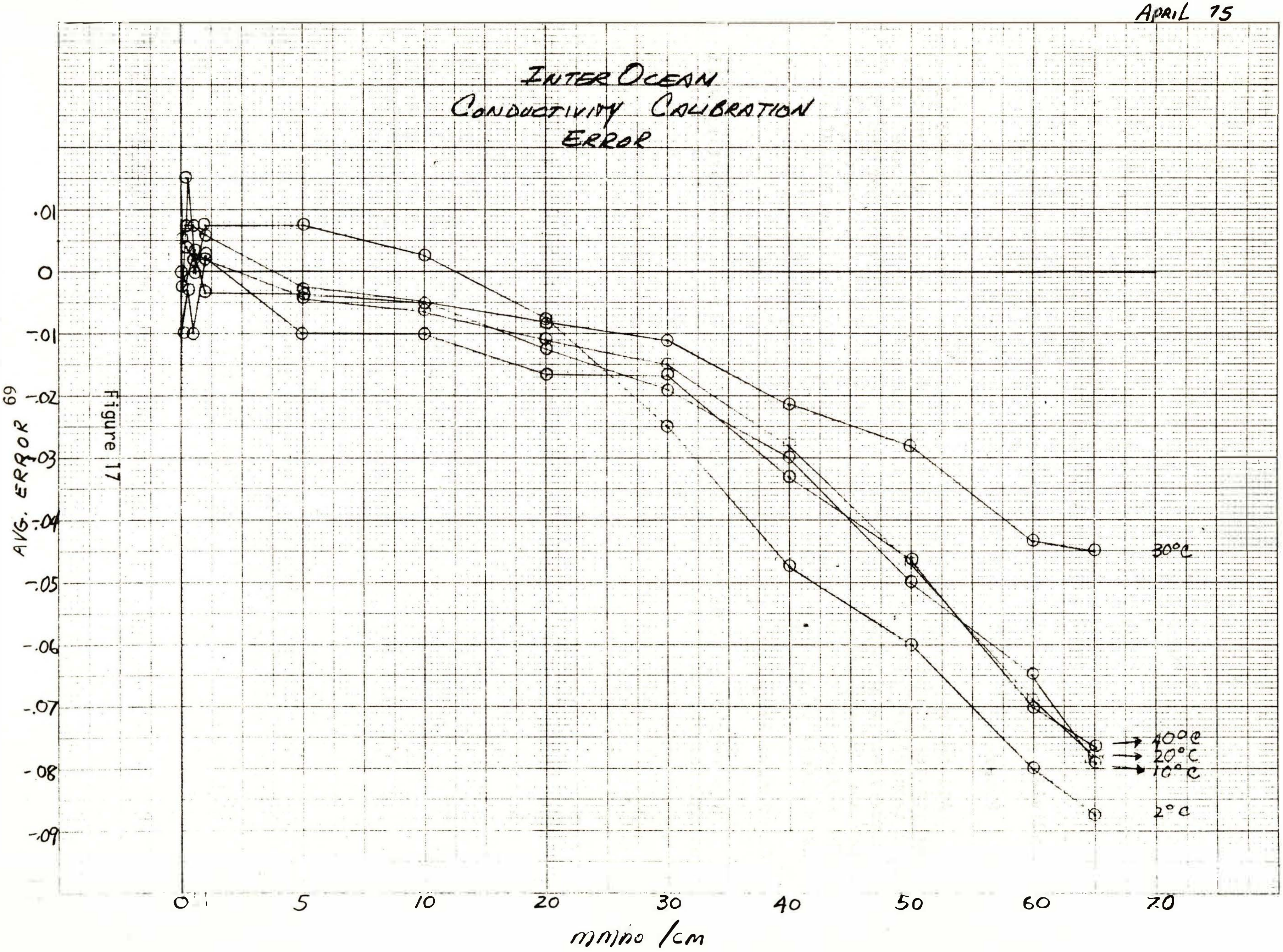

APRIL 75
INTER OCEAN
CONDUCTIVITY CALIBRATION
ERROR
AVG. ERROR
·01
0
-·01
-·02
-·03
-·04
-·05
-·06
-·07
-·08
-·09
0
5
10
20
30
40
50
60
70
mmho /cm
30°C
10°C
20°C
10°C
2°C

Figure 17

International Biophysics Corp. Model DOA 170-051

Martek DDO

Yellow Springs Model 57

Rexnord (Weston and Stack) Model 330

Individual specifications are summarized in Table V.

B. Progress

All tests have been completed, however, data from the dissolved oxygen tests have not yet been reduced. Response time as a function of temperature are shown in figure 18; environmental effects are summarized in figure 19; effect of power supply variation for the Beckman, Delta, IBC and YSI units are shown in figures 20 through 23. The Martek and Rexnord units exhibited less than 0.02 ppm variation as a result of ±20% variation in the supply power.

C. Future Plans

IFS reports will be prepared on all units; some field testing will be carried out on a time available basis.

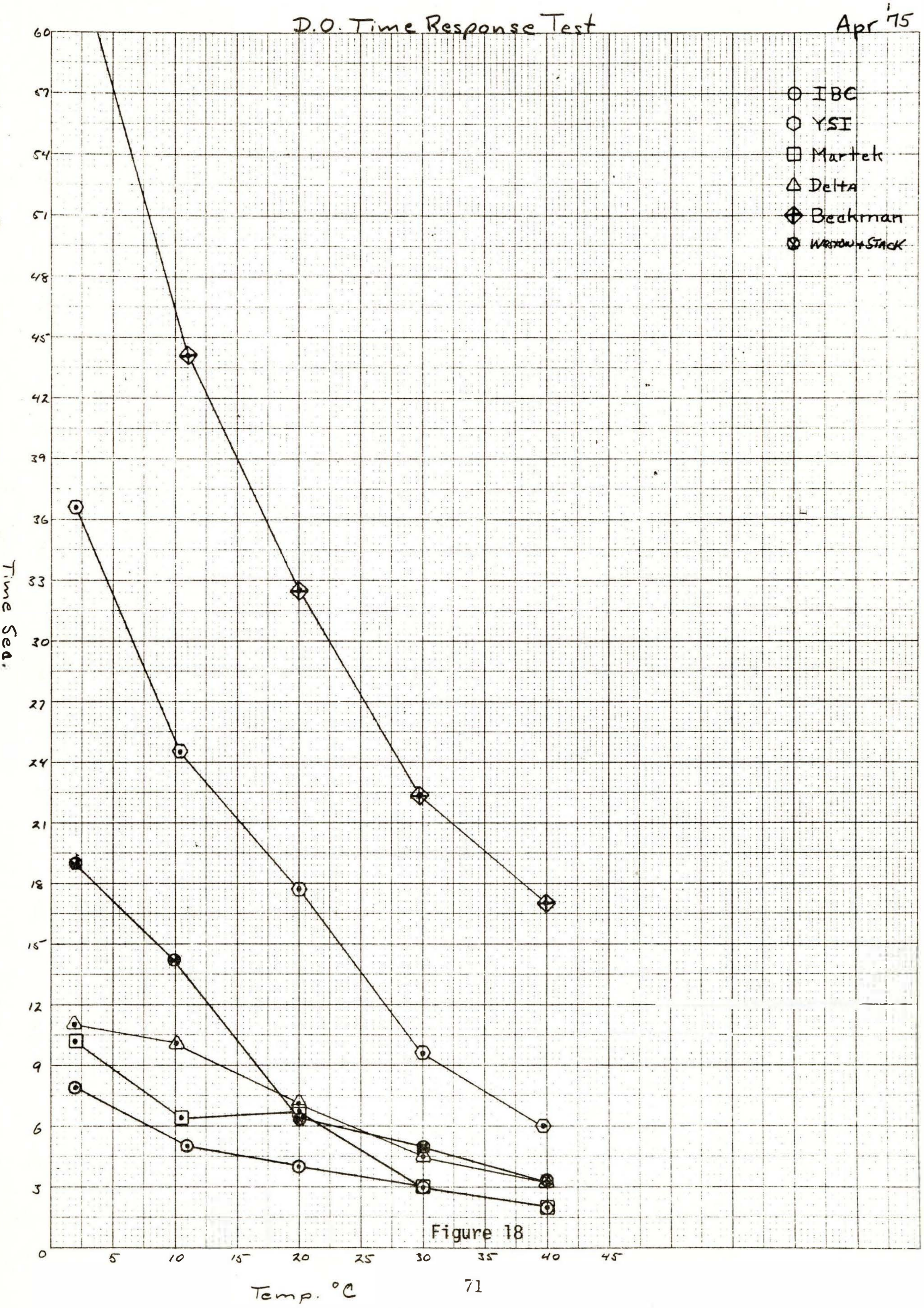

D.O. Time Response Test
Apr '75
Time Sec.
Temp. °C
60
57
54
51
48
45
42
39
36
33
30
27
24
21
18
15
12
9
6
3
0
5
10
15
20
25
30
35
40
45
IBC
YSI
Martek
Delta
Beckman
WRIGHT + STACK

Figure 18

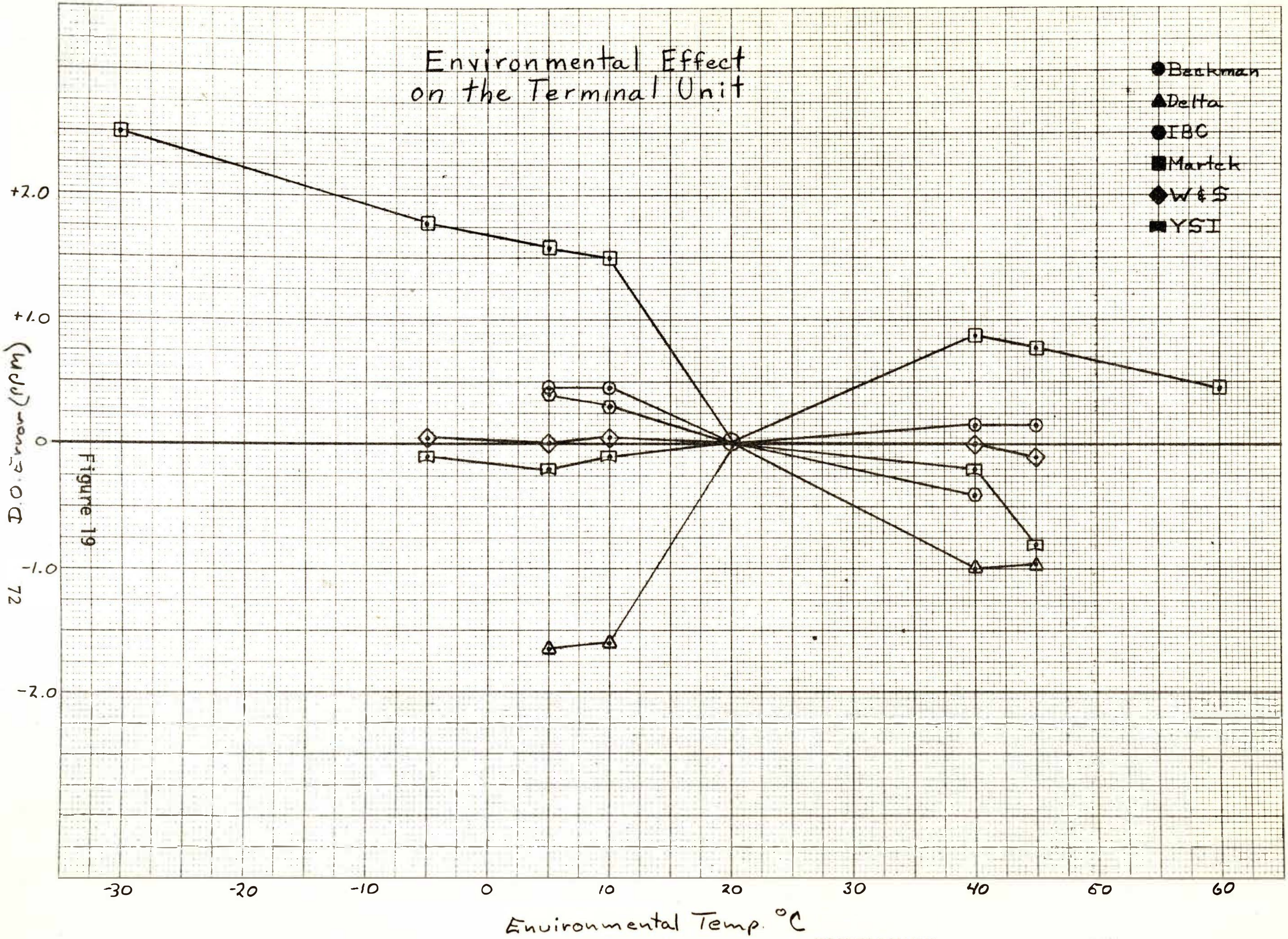

Environmental Effect
on the Terminal Unit
●Beckman
▲Delta
●IBC
■Martek
◆W&S
■YSI
D.O. Error (PPM)
+2.0
+1.0
0
-1.0
-2.0
-30
-20
-10
0
10
20
30
40
50
60
Environmental Temp. °C

Figure 19

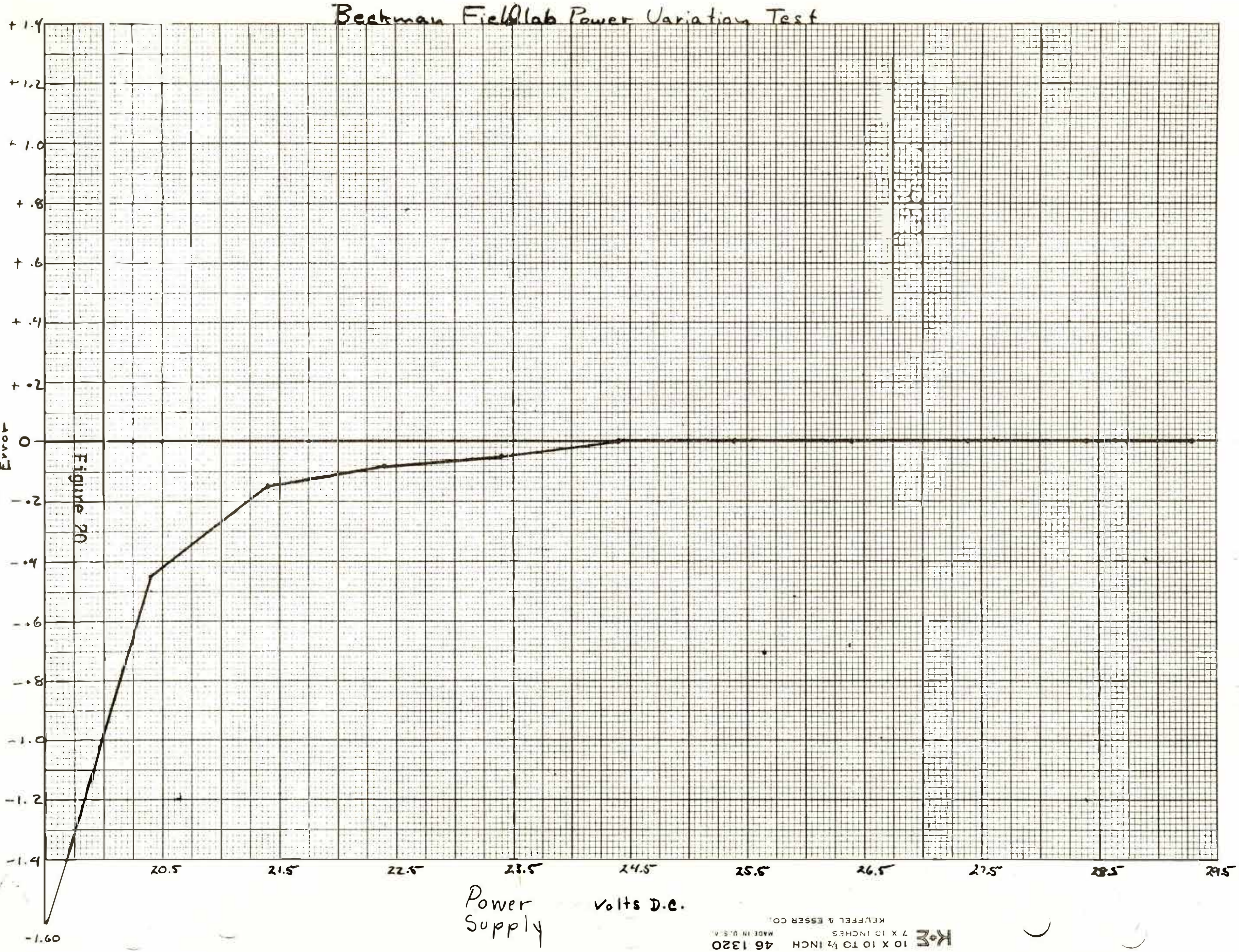
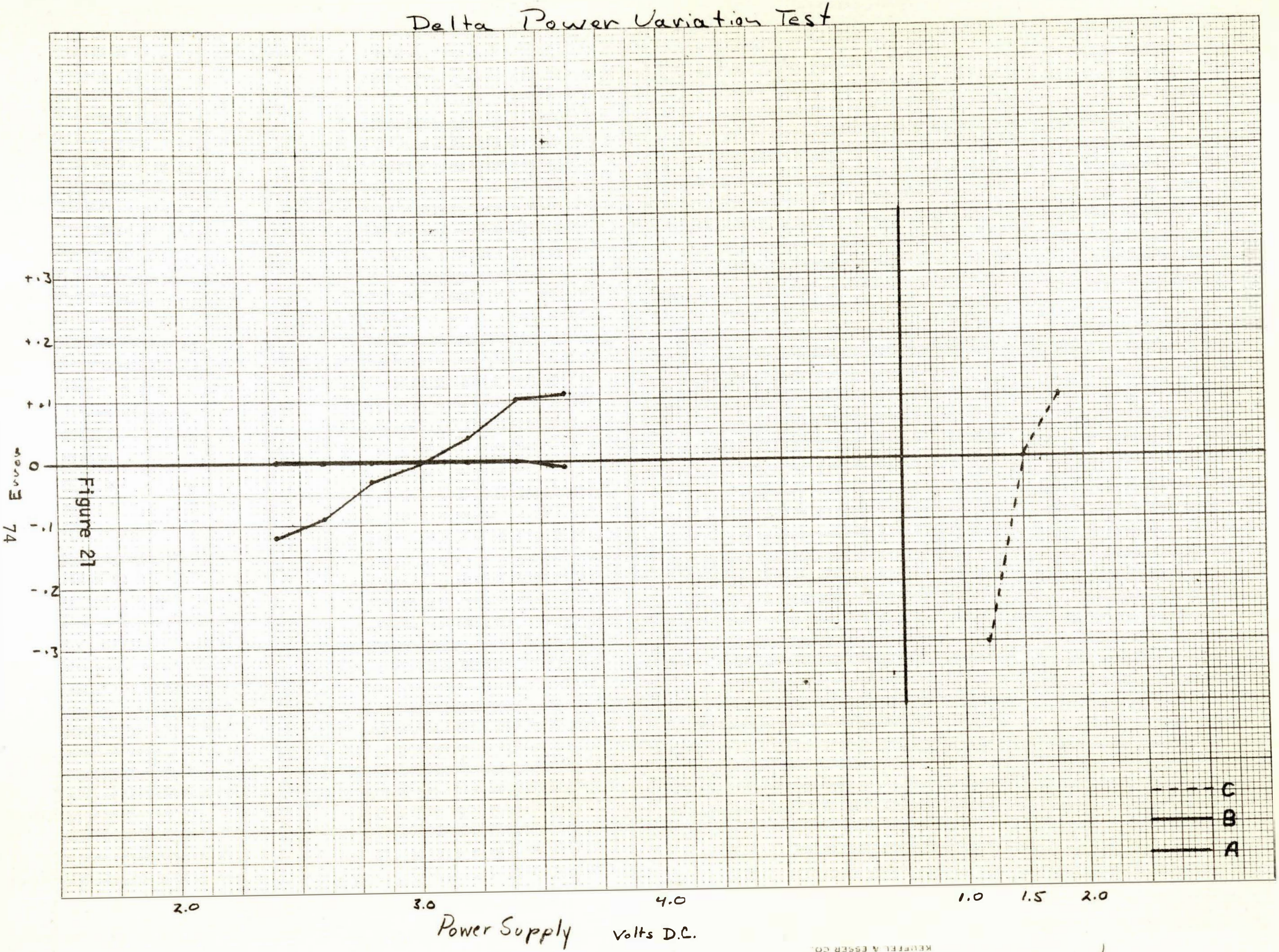

Beckman Fieldlab Power Variation Test
+1.4
+1.2
+1.0
+.8
+.6
+.4
+.2
0
-.2
-.4
-.6
-.8
-1.0
-1.2
-1.4
-1.60
Error
20.5
21.5
22.5
23.5
24.5
25.5
26.5
27.5
28.5
29.5
Power Supply
Volts D.C.

Figure 20



Delta Power Variation Test
+.3
+.2
+.1
0
-.1
-.2
-.3
Error
2.0
3.0
4.0
1.0
1.5
2.0
Power Supply Volts D.C.
C
B
A

Figure 27

IBC Power Variations Test

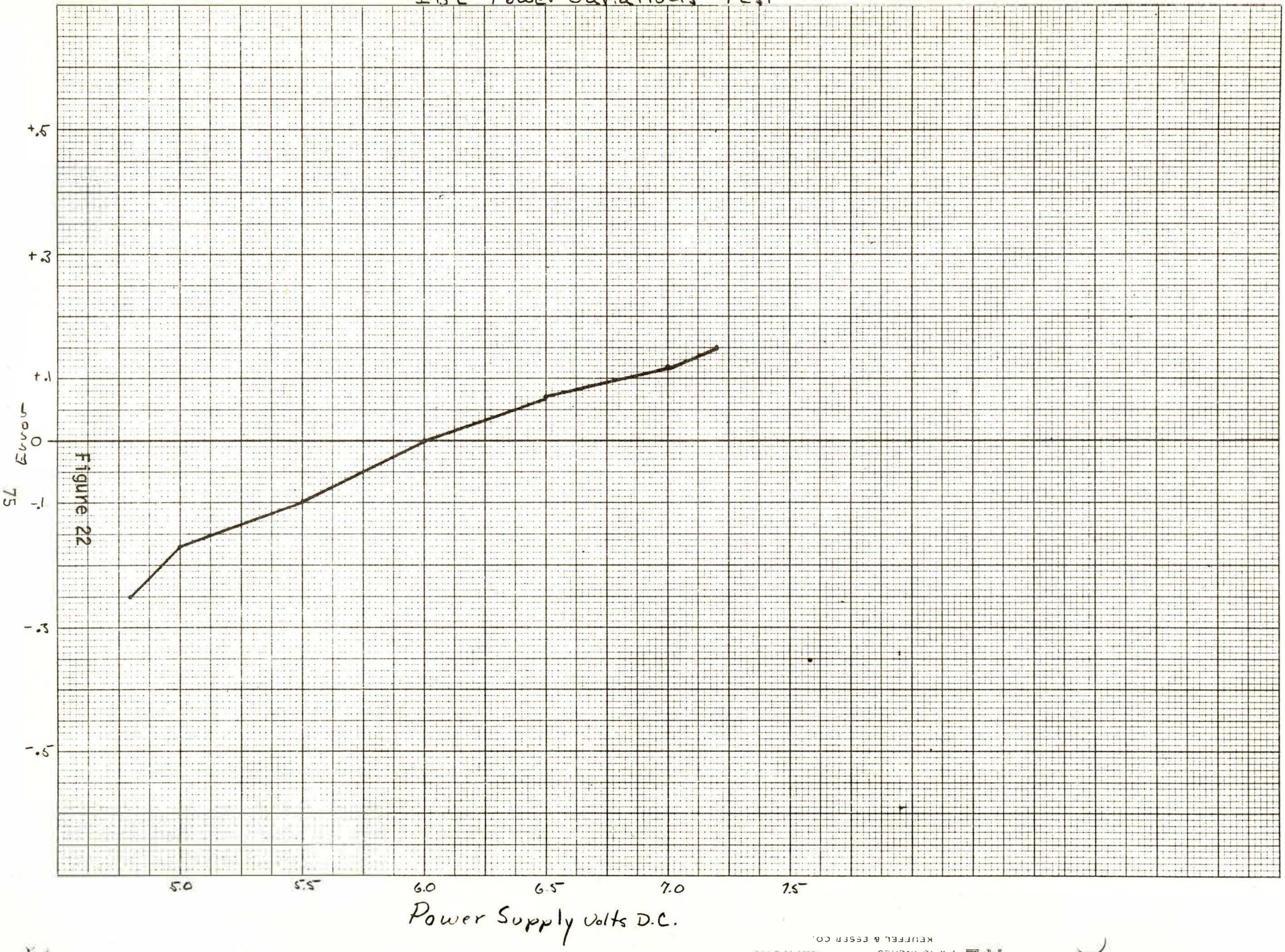


Figure 22

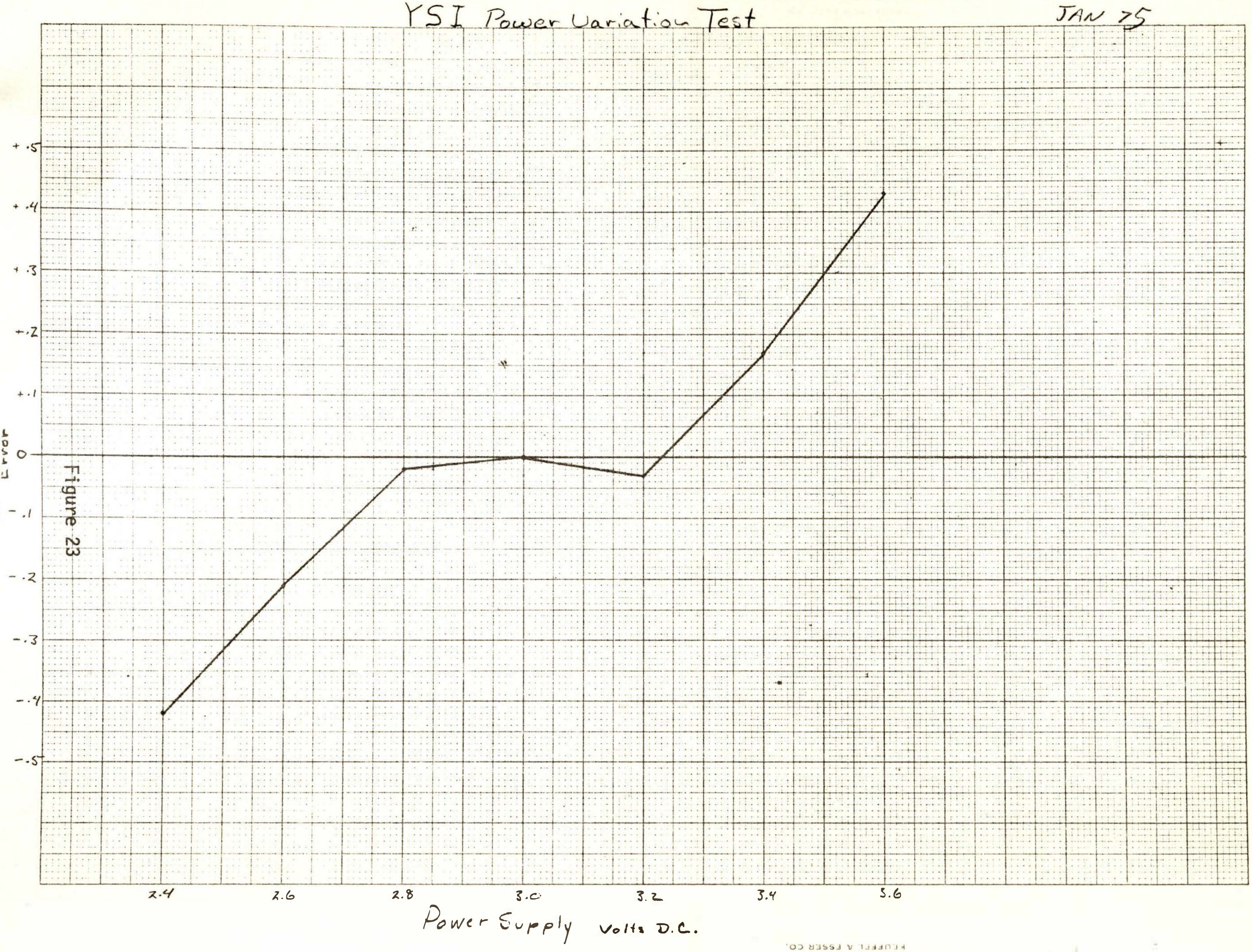
YSI Power Variation Test
JAN 75
+.5
+.4
+.3
+.2
+.1
0
-.1
-.2
-.3
-.4
-.5
Error
2.4
2.6
2.8
3.0
3.2
3.4
3.6
Power Supply Volts D.C.

Figure 23

WAVE AND TIDE MEASURING INSTRUMENTATION

TESTING PROGRAM

Date: July 1, 1975

Project: Waves and Tides

Project Leader: R. Ribe

N – Navy **R** – Reimbursable
I – In-House **O** – Other

Task Description	FY'75												FY'76												Req'mt.
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	
Improved Baylor Corp. Wave Staff (Model 23766)																■	■	■	■	■	■	■	■	■	I
Western Marine Electronics SLM 15W			■	■	■	■	■	■	■	■	■	■	■	■	■										I
Western Marine Electronics Model SLM 9 Water Level Monitor																		■	■	■	■	■	■	■	N
N.O.S. Tide Instrument Studies															■	■	■	■	■	■	■				I
Zwartz (Kelk Model P116) Gage Wave Height Sensor																					■	■	■		I

IMPROVED BAYLOR CORPORATION WAVE STAFF (MODEL 23766)

A. Description

This is a wave staff, complete with power supply, staff, signal processing, and an analog, strip-chart recorder. The staff consists of twin, parallel, 1/2 inch-diameter, stainless steel, wire ropes spaced nine inches apart and offered in lengths up to 100 feet. Ocean tests by Coastal Engineering Research Center show that fouling is much less a problem with this parallel cable design.

A sealed transducer electronics package is mounted at the upper end of the staff cables. The lower ends of the staff cables are electrically and mechanically shorted together. These cables function as a section of shorted transmission line. The transducer generates a radio frequency sine wave of approximately 650 kHz and sends this stimulus down the staff cables. The wave length at this frequency is much longer than the staff cable length. The voltage amplitude of this sine wave is proportional to the length of wave staff above the water surface. This sine wave is rectified and variations in amplitude used as a measure of variations in water wave height.

Power source for the system is 115 V., 60 Hz. No timer-programmer of strip-chart speed or operation is provided, although recorder-chart speed can be changed manually in incremental fashion.

B. Progress

No work on this system during this reporting period. Evaluation work was conducted on an earlier design of this instrument but work was suspended when the instrument was modified.

C. Future Plans

Evaluation will start in September 1975 with accuracy tests and power supply variations to be studied first.

WESTERN MARINE ELECTRONICS MODEL SLM15W WAVE HEIGHT LEVEL MONITOR

A. Description

The Western Marine Electronics Model SLM15W is a variation of a device used to measure level of stored liquids. It has all solid state electronics and contains circuits for measurement of the transit time interval of sound from the transducer down to the ocean surface.

The electronics sends a series of pulses to the ceramic piezoelectric transducer, which are transformed into acoustical pulses. The echoes received from the ocean surface by the same transducer are detected and amplified. The electronics then produce a DC voltage and current output proportional to wave height. The modified unit being tested is a prototype. Transmitted pulses are specified as modulation of 12 kHz carrier with 12 degree beam width. Range of measurement is from 3 feet to 23 feet from the transducer.

B. Progress

Basic calibration and long-term stability tests were conducted (Figure 24) using as a target, a sheet of plywood perpendicular to the acoustic beam.

Tests of increased precision were made to determine ability to detect a plywood disk placed across the beam (Figure 25).

Variation of frequency and amplitude of line power into the SLM15W caused negligible measurement error for combinations of 50 to 70 Hz and 105 to 125 Vrms.

Instantaneous power output from the transducer was measured at 104.8 dB relative to 0.0002 μbar (0.00002 Pa) at one meter. The electrical output pulse to the transducer is nearly a square envelope consisting of six oscillations at 12.5 kHz and 257 volts peak-to-peak.

Transducer directivity was measured as shown in Figure 26.

C. Future Plans

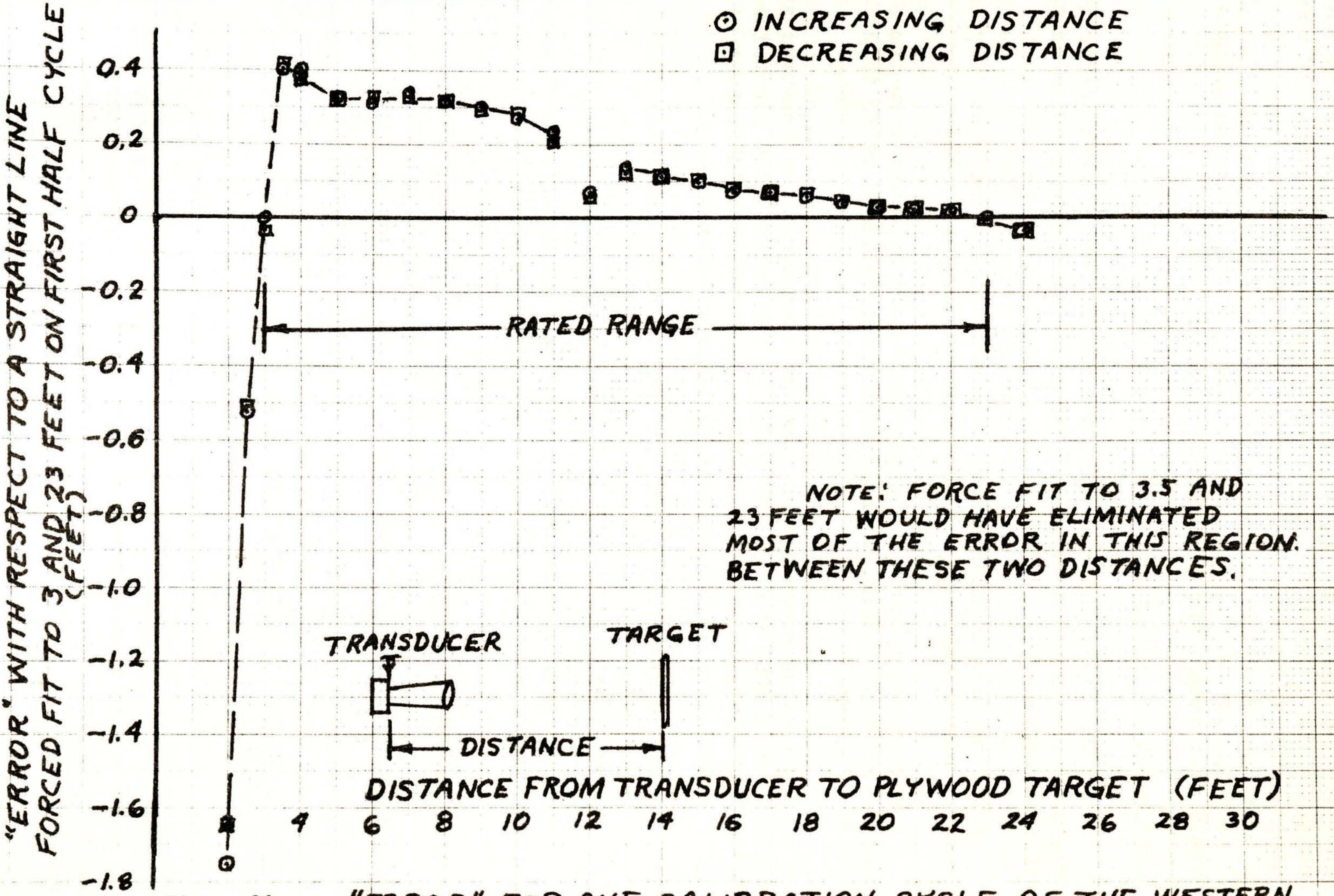
Continue with the evaluation with emphasis on effects of air and instrument temperature changes and water surface conditions.

WESTERN MARINE ELECTRONICS MODEL SLM9 WATER LEVEL MONITOR

A. Description

The model SLM9 consists of a plastic-encapsulated piezo-transducer and associated solid-state electronic circuitry including pulse generating, return-signal processing, pulse transit-time measurement and power-supply circuits.

The transducer is mounted above the water surface and directs ultrasonic (carrier) pulses downward to be reflected off the water. The return pulses are received by the transducer, amplified and shaped and applied to circuitry for measurement of transit time from the transducer to the water. Output is an analog voltage or current with amplitude a function of water level.



NOTE: FORCE FIT TO 3.5 AND 23 FEET WOULD HAVE ELIMINATED MOST OF THE ERROR IN THIS REGION BETWEEN THESE TWO DISTANCES.

Figure 24 - "ERROR" FOR ONE CALIBRATION CYCLE OF THE WESTERN MARINE ELECTRONICS, MODEL SLM15W, WAVE HEIGHT LEVEL MONITOR.

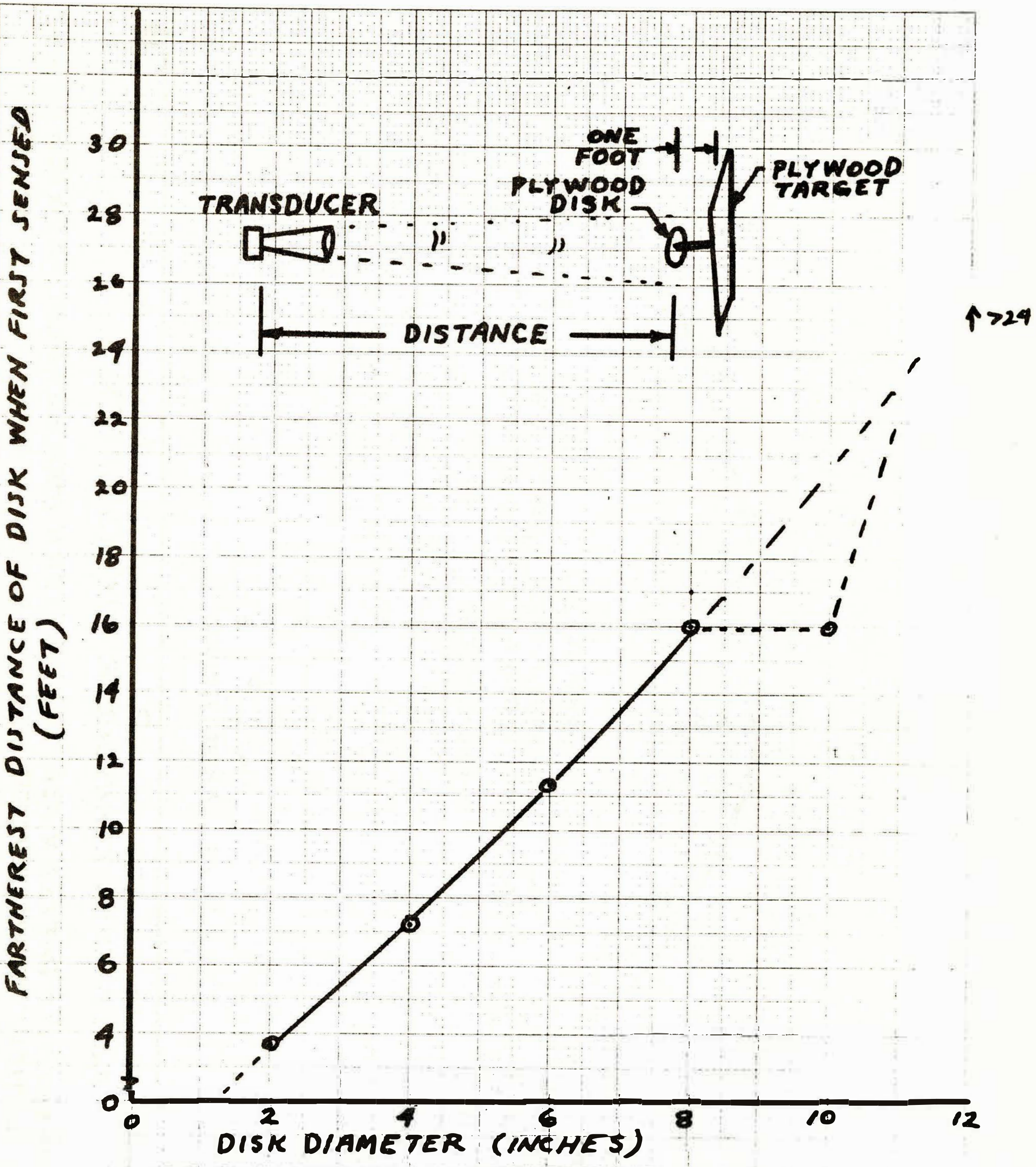


Figure 25 - ABILITY OF THE WESTERN MARINE ELECTRONICS, MODEL SLM15W TO DETECT A PLYWOOD DISK PLACED ACROSS THE ACOUSTIC BEAM CENTER LINE.

6/25/75

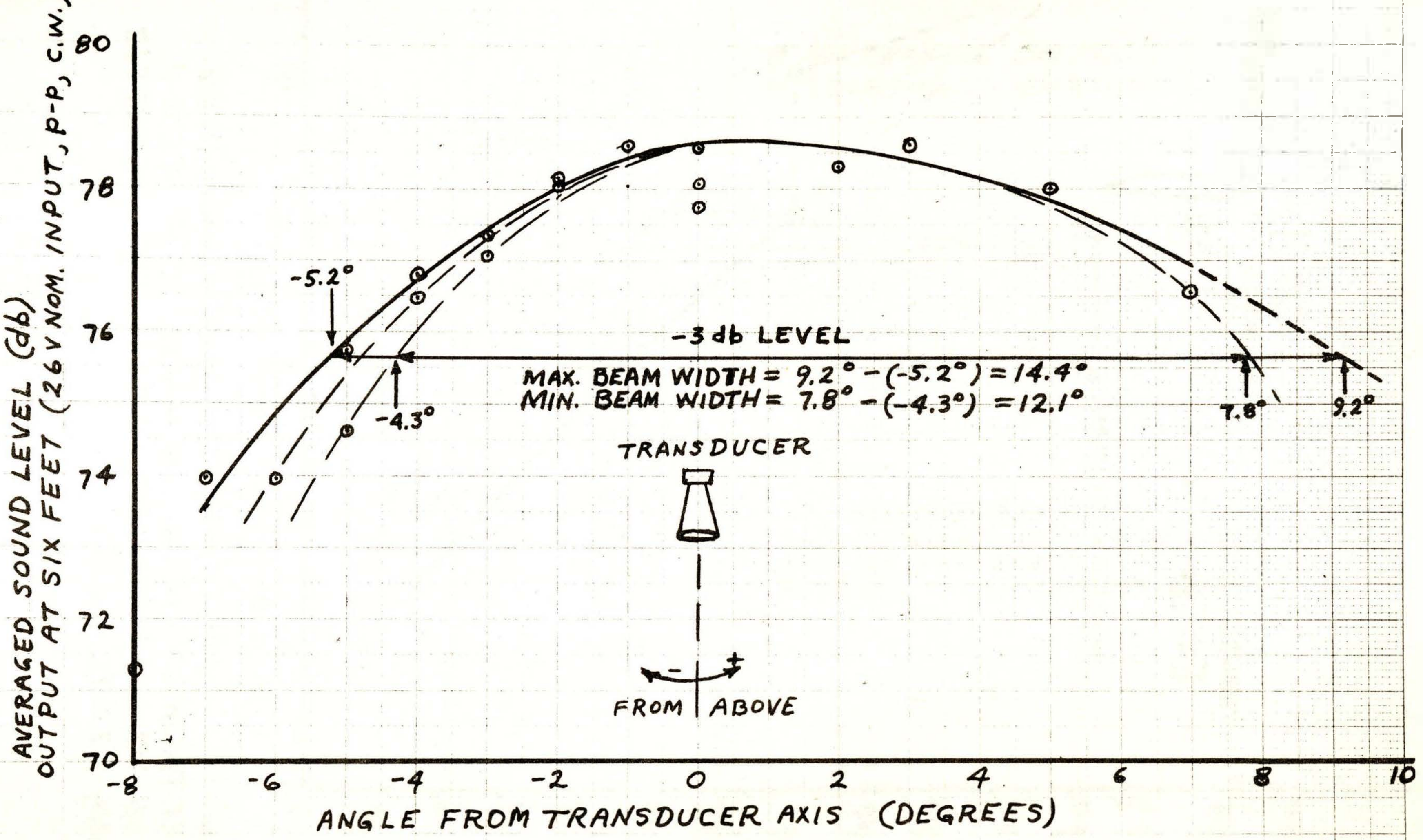


Figure 26-DIRECTIVITY PATTERN FOR THE WESTERN MARINE ELECTRONICS MODEL SLM15W TRANSDUCER.

The SLM9 can be used to measure tide levels and water levels in flumes, etc. It is lightweight and quite portable. No elaborate installation is required for many applications. Input power is 110/220 VAC, 50-60 Hz, 10 watts. Measurement range is rated at three meters.

B. Progress

Preliminary planning is being conducted.

C. Future Plans

Start of testing is planned for November 1975 with accuracy, temperature effects, and general capabilities emphasized.

N.O.S. TIDE INSTRUMENT STUDIES

A. Description

The Fischer and Porter Company, model 1550, Punched Tape Level Recorder is in extensive use. This tide gauge uses a stilling well with a float mechanically linked to coded disks. The disk code is punched into paper tape at preselected time intervals obtained from a timer in the instrument.

B. Progress

Preparations are being made for evaluation of this Fischer and Porter Company gauge. Apparatus is being fabricated for tests of effects of steady water currents on water level in stilling wells.

C. Future Plans

Accuracy and environmental-effects tests will be conducted on the Fischer and Porter Company gauge. Tentative plans for evaluation of the Bristol Company Bubbler Tide Gauge and Leupold-Stevens Tide Gauge have also been made.

ZWARTZ (KELK MODEL P116) GAGE WAVE HEIGHT SENSOR

A. Description

The wave staff consists of concentric pipes serving as a coaxial transmission line for electromagnetic square waves created by a tunnel-diode oscillator. Frequency of oscillation is dependent on amount of exposed wave staff, since the staff is part of the oscillator circuitry.

The frequency is converted to an analog voltage as a measure of wave height by electronics provided. The Wave Height Sensor can be used in either fresh or salt water.

B. Progress

Preliminary planning is being conducted.

C. Future Plans

Start evaluation about March 1976.

APPENDIX A

GENERAL TEST PLAN

BATHYMETRIC RECORDERS

Tests to be performed:

1. Manufacturer's Checkout Procedure
2. Receiver Bandwidth
3. Receiver Self-Noise
4. Minimum Detectable Level (MDL)
5. Signal-to-Noise Ratio (SNR)
6. Dynamic Range
7. Short-term Stability
8. Long-term Stability
9. Input Impedance
10. Voltage Variation
11. Frequency Variation
12. Power Consumption
13. Chart Speed
14. Temperature
15. Humidity
16. Vibration
17. Field Tests

1. Manufacturer's Checkout Procedure - This test will be conducted in accordance with the manufacturer's procedure as noted in the operating manual. Prior to the test and evaluation set the controls of the recorder to positions indicated by the manufacturer and perform the recommended checkout procedure to determine the operating condition of the equipment.

2. Receiver Bandwidth - This test will determine the receiver bandwidth as a function of the receiver gain. The test is conducted by driving the receiver input with a constant amplitude sweep oscillator and measuring the output signal on an VMS voltmeter. The voltmeter output is fed to a dB converter and plotted on the Y axis of an XY recorder. The X-axis is either a linear or log sweep of the frequency derived from the sweep oscillator. The test is repeated for different gain settings of the receiver amplifier.

   Equipment Required - Sweep oscillator, RMS voltmeter, dB converter, X-Y recorder.

3. Receiver Self-Noise - This test is run to determine the receiver self noise as a function of the receiver gain and various sweep speeds. The input terminals are shorted to ground and rms voltmeter is connected to the receiver output amplifier prior to the print amplifier. The noise is recorded as a function of various receiver gain settings and at several of the faster sweep speeds. Typically the dominant noise component will be at the line frequency and will be considerably higher than the MDL level of a simulated return signal; however, the MDL signal can still be detected on the recorder display by differentiating this signal from the random and irregular display of the receiver self-noise signal.

   Equipment Required - RMS voltmeter.

4. Minimum Detectable Level (MDL) - This test will determine the minimum level of a received signal that can be detected with the receiver controls optimized. The frequency of the test signal is selected to be in the center of the receiver pass-band as noted in test #2 or as specified by the manufacturer; for most bathymetric recorders this frequency is 12 kHz. The simulated return signal is derived from the recorder keying signal which is passed through a delay circuit that triggers a variable width pulse generator. The generator triggers a gate that transmits the 12 kHz tone burst which is typically 0.5 - 1.0 msec. long. This signal which has been adjusted to 0 dB is fed through an attenuator into the receiver input. (If the impedance between the attenuator and the receiver cannot be matched by a line transformer, the attenuator will have to be calibrated to to determine the correction factors for the attenuator). The level of the simulated return signal is reduced and positioned in a random manner on the display until a MDL condition can be detected for a

nominal observation interval of 5 minutes at sweep speeds of 0.25 and 0.50 sec. The recorder controls are optimized to detect the signal with the receiver gain -- maximum, threshold-minimum, and chart rate speed control -- minimum.

Equipment Required - Delay generator, pulse generator, signal gate, attenuator and impedance matching transformer (optional).

5. Signal-to-Noise Ratio (SNR) - This test is run to determine how much interference the recorder can accept with the return signal and still record an identifiable trace on the display. A summing amplifier is inserted between the signal gate and attenuator described in #4. A pseudo-random Gaussian noise source and attenuator is connected to the summing amplifier in addition to the simulated test signal and the attenuators are recalibrated if required. The signal is increased so that it is above the MDL and can be readily identified. The level of the noise source is increased until an MDL condition is observed over the observation interval and sweep speeds listed in #4. During this test the position of the simulated test signal is changed in a random manner prior to an observation interval. The test is repeated for different signal levels within the dynamic range of the receiver section. In calculating the effective noise level, the receiver bandwidth must be considered.

   Equipment Required - Same as #4 in addition a random noise source, summing amplifier, additional attenuator and RMS voltmeter.

6. Dynamic Range - The dynamic range of the recorder is determined by connecting the random noise generator to the receiver input and increasing this level in 6 dB increments until the observer can no longer distinguish a contrast difference between succeeding displays. At this point, the receiver amplifiers have saturated and the dynamic range is defined from the MDL level found in #4 to the saturation level found in this test. The dynamic range is repeated for different sweep speeds and should decrease somewhat as the sweep speed is increased.

   Equipment Required - Random noise generator, attenuator and line matching transformer (optional).

7. Short-term Stability - The stability of the recorder clock will be determined using the HP Computing Counter and reducing the data according to the HP "Computing Counter Applications Library Note #7", published in March, 1970. The short-term stability of the motor drive and other reference frequencies will also be determined if the monitor jacks are readily available. The minimum averaging time of the computing counter will be set near the fastest sweep speed of the recorder and 1,000 sample points will be taken at each data point.

   Equipment Required - see attached application note.

8. Long-term Stability - In this test the recorder clock frequency drift will be compared to a cesium beam standard connected to the receiver input over an 8-hour period at a selected sweep speed.

   Equipment Required - Cesium beam standard.

9. Input Impedance - The input impedance for various receiver input jacks will be determined by connecting an oscillator set to the center of the receiver passband through a variable decade resistor to the input terminal of interest and varying the decade resistance until the oscillator signal is equally distributed between the decade resistance and the receiver input jack. The decade resistance box will then indicate the receiver jack input resistance. The test will be repeated for the half power frequencies and also for any discrete frequency that is specified by the manufacturer. For input jacks where the input impedance may be affected by the receiver gain setting this test will be repeated for several different gain settings.

   Equipment Required - Oscillator, decade resistance box, RMS voltmeter.

10. Voltage Variation - This test is conducted by connecting the recorder line voltage plug to a variac or programmable power supply and changing the voltage in 5 volt increments within the manufacturer's specified line voltage range. The recorder is operated for a minimum period of 5 minutes and all recorder functions are observed for any indication of improper operation.

    Equipment Required - Variac and voltmeter.

11. Frequency Variation - This test is conducted by connecting the recorder line voltage plug to a frequency charger or programmable power supply and changing the frequency in 5 Hz intervals within the manufacturer's specified frequency range. The recorder is operated for a minimum period of 5 minutes and all recorder functions are observed for any indication of improper operation. Larger frequency increments may be used when a range of 50 to 400 Hz is indicated. At the endpoints of the specified frequency range the line voltage is varied in the specified range and the recorder operation is again checked.

    Equipment Required - Frequency changer, frequency counter, voltmeter.

12. Power Consumption - This test is run by connecting a wattmeter between the recorder and the line voltage. Power is applied and the wattmeter readings are recorded in all modes of operation, (i.e., various print modes, event marker, time marker, chart rate, speed variation, etc.).

    Equipment Required - Wattmeter.

13. Chart Speed - This test is run to determine the chart speed as a func-

tion of all sweep speeds and as a function of the minimum, midscale, and maximum chart rate speed control.

Equipment Required - Stop watch or electronic counter.

14. Temperature - This test is conducted in the Parce Environmental Chamber. A simulated return signal is applied to the receiver input and the temperature is cycles from 0°C to 40°C, starting at an ambient temperature of 25°C. The recorder functions and the simulated return signal and the clock short-terms stability shall be observed for a 5-minute interval after temperature equilibrium has occurred at 0°, 5°, 15°, 25°, 35°, and 40°. The humidity will be maintained at 50% during this test.

    Equipment Required - Same as #4 and #7.

15. Humidity - This test will also be run in the Parce Environmental Chamber. The humidity shall be cycled from 20% to 90% and the temperature will be maintained at 25°C. After equilibrium has occurred the parameters noted in #14 shall be observed. After completion of this test the recorder will be operated at 40°C and 90% R.H. for one hour to note if any malfunctions or failures occur.

    Equipment Required - Same as #4 and #7.

16. Vibration - This test will be run according to MIL-STD-167, Type I, environmental vibration. The parameters listed in #14 shall be observed at each vibration frequency and during the two-hour endurance test.

    Equipment Required - Same as #4 and #7.

17. Field Tests - For this operational test, the recorder will be installed and operated in the ship's bathymetric system either in line as the only recorder or in parallel with the ship's recorder. The recorder will be operated continuously during the vessel transit and its capability to resolve and display the bottom terrain will be evaluated under various environmental conditions.

APPENDIX B

GENERAL TEST PLAN

DIGITAL DEPTH TRACKERS

TESTS TO BE PERFORMED:

1. Manufacturer's Checkout Procedure.
2. Threshold.
3. SNR vs. specified false-alarm probability, p(FA).
4. Tracking capability in gradients vs. SNR for specified p(FA) rates.
5. Input/Output Impedance.
6. Voltage Variation.
7. Power Consumption.
8. Temperature
9. Humidity.
10. Field Tests.

1. Manufacturer's Checkout Procedure - This test will be conducted in accordance with the manufacturer's procedure as noted in the operating manual. The proper functioning of all controls and the overall operation of the digital depth tracker shall be verified prior to the test and evaluation.

2. Threshold - This test will determine the minimum return signal level that can be accurately processed by the digital depth tracker. The simulated return signal is derived from the recorder keying or sync signal which is passed through a delay circuit that triggers a variable pulse width generator. The generator triggers a gate that transmits the tone burst at the specified frequency. This signal is processed as required and applied to the input stage of the tracker. The signal level is decreased until the tracker fails to operate properly or until a specified false-alarm probability rate p(FA) is achieved. The p(FA) rate will be determined using a data acquisition system which will be programmed to calculate the rate from 1000 data points per input signal level attenuation. Histogram or probability density function (pdf) curves will be made available if requested for signal level settings of interest. A description of the data acquisition system used in the evaluation is enclosed.

   Equipment Required - delay generator, pulse generator, signal gate, attenuator, impedance matching transformer (optional), signal inverter (as required.

3. SNR For Specified False-Alarm Probability, p(FA). - This test will determine the minimum signal to noise ratio required for proper operation at a specified p(FA). Pseudo random Gaussian noise with impulsive components will be added to the return signal through a summing amplifier and applied to the tracker input. Different attenuation settings will be tried for the signal, noise, and impulsive components and the p(FA) will be calculated for each setting as in test #2. The attenuator settings will be varied until the specified p(FA) is achieved. In some digital trackers, very short impulsive noise spikes and very short echo pulses are suppressed by the signal processing circuits and should not be sensitive to the high level impulsive components.

   Equipment Required - Same as test #2 in addition summing amplifier, and attenuators.

4. Tracking Capability vs. SNR For Specified p(FA) Rates - This test is similar to #3 except that instead of a simulated flat bottom signal return the return signal is processed to simulate steeper gradients. The electronic circuitry will be developed to simulate gradients of 10°, 30°, 45°, and 60° and the SNR ratios will again be determined for the specified p(FA) rates.

   Equipment Required - Same as #3.

5. Input/Output Impedance - the input impedance for the digital tracker will be determined by connecting an oscillator set to the manufacturer specified frequency through a variable decade resistor to the input

stage and varying the decade resistance until the oscillator signal is equally distributed between the decade resistance and the input stage. The decade resistance box will then indicate the input stage impedance. The output impedance will be determined by applying a simulated depth signal to the tracking unit and connecting a decade resistance box to the output. The decade resistance will be varied until the digital signal level has dropped to one half of its no load level as monitored by an rms voltmeter or oscilloscope.

Equipment Required - Oscillator, decade resistance box, rms voltmeter, oscilloscope.

6. Voltage Variation - This test is conducted by connecting the tracker power leads to a variable power supply and changing the voltage in increments within the manufacturer's specified voltage range. A simulated return signal is applied to the tracker and the tracker output signal is monitored for any degradation or malfunctions in the specified voltage range.

   Equipment Required - Laboratory power supply, voltmeter.

7. Power Consumption - This test is run measuring the dc voltage and current required to operate the tracker in various modes. The power dissipated is computed from the measurements taken.

   Equipment Required - Voltmeter, current probe and amplifier, and oscilloscope.

8. Temperature - This test is conducted in the Parce Environmental Chamber. A simulated return signal is applied to the tracker input and in the absence of a manufacturer's specified temperature range or user requirements, the unit is cycled from 0°C to 40°C from an ambient temperature of 25°C. The tracker functions and operational modes are observed at 0°, 5°, 15°, 25°, 35°, and 40° after temperature equilibrium has occurred. The humidity will be maintained at 50% during the temperature cycle.

   Equipment Required - Same as #2.

9. Humidity - This test will also be run in the Parce Environmental Chamber. The humidity shall be cycled from 20% to 90% in 20% increments and the temperature will be maintained at 25°C in the absence of a manufacturer's specified humidity range or user requirements. After equilibrium has occurred the parameters noted in test #8 shall be observed. After completion of this test the tracker will be operated at 40°C and 90% R.H. for one hour to note if any malfunctions or failures occur.

   Equipment Required - Same as test #8.

10. Field Tests - For this operational test the tracker (and specific bathymetric recorder if required) will be installed and operated in the ship's bathymetric system either in line as the only recorder or

in parallel with the ship's recorder. The tracker will be operated at specific times under different environmental conditions during the vessel transit and the tracker input signal will be recorded on magnetic tape while the digital output signal will be recorded on an incremental tape recorder. This data will be analyzed after the field test to determine the p(FA) rates, and the SNR ratios experienced during the field testing phase.

Equipment Required - Tape recorder (direct mode record capability), incremental tape recorder.